

ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

Edmund

LEWIS STEPHEN PILCHER, M.D., LL.D.
of New York

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With the Collaboration of

SIR WILLIAM MACLEWEN M.D., LL.D.

W.H. CLAYTON GREENE, F.R.C.S.

of Glasgow

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MONTREAL PHILADELPHIA LONDON

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ANNALS *of* SURGERY

VOL. LXXIV

OCTOBER, 1921

No. 4

SOME RESEARCHES ON THE PERI-ARTERIAL SYMPATHETICS*

BY RENE LERICHE, M.D.
OF LYONS, FRANCE

THE sympathetic nervous plexuses included in the external layer of blood-vessels seem to possess a real autonomy. The systematic study of the phenomena which follow the exciting of average-sized arteries, that is, of prevailing muscular structure, reveals the existence of a very characteristic physiological reaction which never fails in normal circumstances.

A knowledge of the constituents of this reaction is quite interesting from the triple point of view of physiology, pathology and therapeutics; it sets new problems in physiology; it permits us to explain certain pathological phenomena; finally, it authorizes some promising therapeutic attempts.

I feel the best way I can express my thanks for the great honor the American Surgical Association has done me in inviting me to take part in their work is to present to it the results of my researches on this subject, these last few years.

I. When you remove the sheath of an artery, the brachial artery for instance, you see, just at the moment its external layer is pinched, the vessel contracts, its pulsation stops at once and its size diminishes. If you excise the cellular layer the diminution will progressively reach the third or the fourth of the normal size of the artery. The segments on both sides maintain their normal size provided the operation has not injured them.

This arterial contraction usually causes the pulse to disappear, but it does not altogether interrupt the circulation.

If the artery is cut a thin thread of blood is seen inside; on the other hand, if during the experiment capillaries are examined by Weiss's method, you will see, at the moment the arterial contraction takes place, the capillary loop diminish regularly in its whole length, pale but remaining visible. If the artery is tied the loop is almost indistinguishable, though a little blood still passes (Fig. 1).

The arterial contraction is the primary element of the characteristic physiological reaction against excitation (Fig. 2).

SECONDARY SIGNS.—In the following hours pulsation is imperceptible or very feeble; the operated limb is colder than the other; there is a difference

* Read before the American Surgical Association, June 15, 1921.

of 3° or 4° C. After several hours, varying from three to fifteen, secondary signs appear which form the next element of the characteristic reaction.

They never fail when the excision of the nervous layer is really performed; if they are wanting, it is due to the incompleteness of the nerve operation. Out of sixty-four operations only one failed; in this case, one of my first, the artery was enclosed in fibrous tissue and did not contract during dissection; thus I had not touched its nervous sheath. The secondary signs are the following:

1. An elevation of local temperature reaching 2° and even 3° C., central temperature not being modified. The patient has a subjective sensation of heat. One of my patients complained the day after operation of "a hell fire" in his hand.

2. An elevation of the arterial pressure, which may reach 4 c.c. of mercury according to the healthy side. Claude Bernard had already noted the same figures when measuring arterial pressure after section of the sympathetic in the neck.



FIG 1.—(1) Aspect of a normal capillary loop in a finger, examined by Weiss' method; (2) diminution of size when the brachial peri-arterial nerve is excited; (3) almost complete disappearance after ligation of the brachial artery.

3. An increasing amplitude of oscillations, shown by the sphygmomanometer.

These statements have been verified on my patients by my friend, Doctor Heitz, one of the most eminent cardiologists of France.

The vasodilator reaction is transitory, after peri-arterial sympathectomy it becomes attenuated from the fifth to the sixth day and disappears after three or four weeks.

Such is the characteristic physiological syndrome of the peri-arterial sympathetics against excitation.

II. Pathologically, this excitation may be provoked as well on visceral arteries as on arteries of limbs, and this by direct traumatic causes or indirect infectious or toxic causes.

Whatever may be the cause, as soon as the peri-arterial sympathetic plexus is injured the physiological reaction appears, in exactly the same way the oculopupillary reaction follows the injury of the cervical sympathetic plexus.

THE PERI-ARTERIAL SYMPATHETICS

At the level of the viscera we know absolutely nothing of these reactions; we may suppose that ischaemia and prolonged vasodilatation with consecutive elevated blood-pressure may disturb the ductless glands for instance, the thyroid or pancreas, but we have no positive experience concerning the subject. The only experimental fact I know is the following: In a case of diffuse oedematous thyroid hypertrophy a unilateral high perithyroidal sympathectomy caused an extreme diminution of size of the corresponding lobe in the next few days. That is a little thing but it allows one to believe there is a very interesting field of future research.

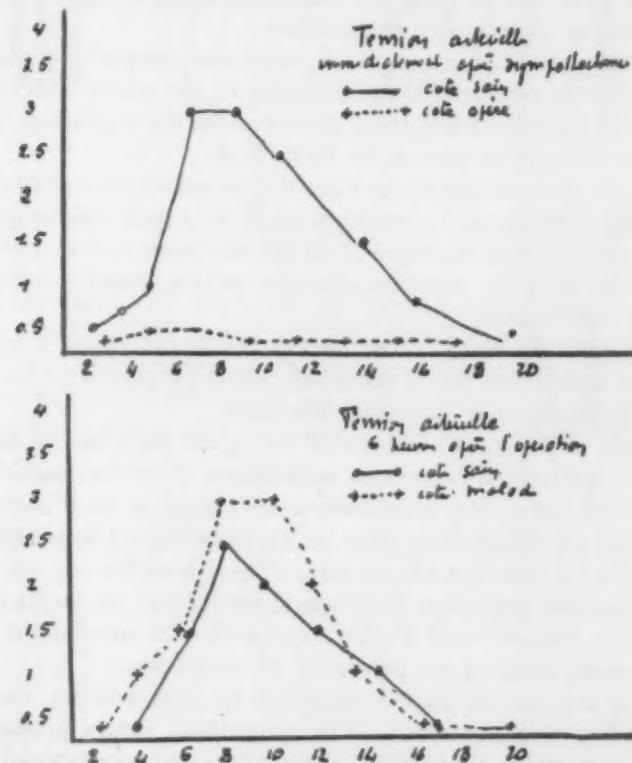


FIG. 2.—(1) Sudden lowering of the arterial pressure immediately after excitation of the peri-arterial sympathicus; (2) rise of the arterial pressure following the preceding phases.

Finally it is only at the level of limbs that we begin to distinguish the phenomena resulting from an injury of the peri-arterial sympathetic plexus, and their analysis is not easy.

To expose them as clearly as possible one may isolate two groups: In the first group the characteristic physiological reaction is pure, with two striking aspects; in the second case, reaction is disturbed and gives various troubles.

First Type. One may choose two characteristic examples, "stupeur des artères" and Raynaud's disease. I will not insist on the well-known syndrome of "stupeur arterielle." It is an active secondary spasm due to sud-

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den excitation of the external arterial layer; a woundless traumatism may produce it as well as a projectile. We have noticed it after violent shock of the humerus, the arm being limp and lifeless, the fingers colorless; one might have thought the brachial artery was crushed. There was really no injury and these phenomena were temporary.

Against Kuttner's opinion I still believe that this contraction is of nervous origin instead of muscular origin, and this for reasons I do not want to develop here.

I want only to make you notice that, in certain cases, the contracture may be so intense as to lead to gangrene from insufficient circulation. This led during the war to unnecessary amputations.

Raynaud's symptoms are typical of vasomotor sympathetic disease. In certain cases of the peri-arterial sympathetics of the whole limb seem to be excited, for the vascular contraction involves even the capillaries, producing deformations that may be seen on the living limb.

This may be observed surgically when the sympathetical irritation is manifest; for instance, in the case of cervical rib or in certain subclavian obliterations (Fig. 4). In these cases the crisis has the exact figure of the physiological reaction with its two characteristic phases, painful ischæmia and consecutive vasodilatation.

Second Type. In many circumstances the initial cause is less known and the physiological reaction is disturbed; either by contracture of too long duration or by abnormally persisting dilatation.

In all cases it produces considerable biological disturbances in the subjacent tissues, creating thus various associations of motor, sensitive, vasomotor, glandular and trophic symptoms, or even signs of local necrosis.

Concerning sensibility there may be no systematized hypoæsthesia, but principally painful causalgic phenomena. These troubles are not provoked by an injury of sensitive nerves but begin at the level of the tactile apparatus. The Meissner's, Paccini's and Ruffini's corpuscles are surrounded by a rich vascular network, insuring the perfection of sensations.

Supposing the vascularization disturbed by inflammation, the nervous apparatus suffers at first contact. The sympathetic injury producing peripheric vasodilatation has the identical effects: thus may be explained the acute pains in Weir Mitchell's causalgia and certain painful stumps.

By a less-known process, injury of the peri-arterial sympathetics may provoke motor troubles, either stiffness and contracture, a kind of hypertony localized to certain muscular groups, or a rapid atrophy.

One has noted in "stupeur arterielle" immediate muscular rigidity. The same contracture was also frequently noticed after war wounds and described under the name of reflex troubles by Babinski and Froment.

In these cases when acting on the peri-arterial sympathetics one has seen motor troubles diminish or even disappear as if the contraction of stripped muscles were dependent on the sympathicus (Fig. 6).

THE PERI-ARTERIAL SYMPATHETICS

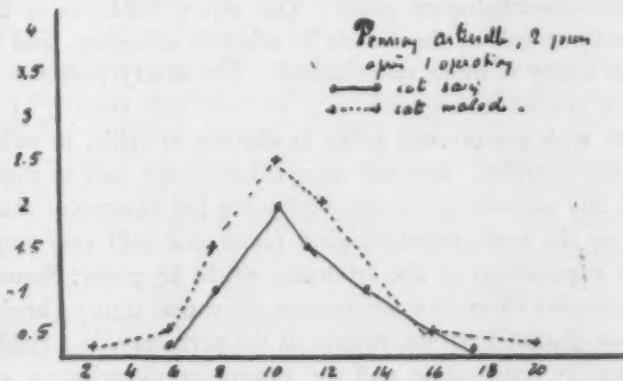
One may believe muscular symptoms to be but consequences of defective circulation and that sympathectomy acted in modifying it; but one must not forget that the histologists admit for the muscles both a myelinic and amyelinic innervation. The influence of the sympathetics on the muscular



FIG. 3.—Figures showing the capillary loaf in a finger and its different sizes before and after Raynaud's disease. (1) Normal; (2 and 3) contracture irrégulière; (4) surdilatation après la cuire.

tonus was shown by De Boer, and the modern neurologists seem to believe that the tonus of muscles at rest is conditioned in invertebrates by the sympathetic system. The presence of motor phenomena is thus easily explained.

In association one frequently notices changes in the sudorific function, profuse sweating or absolute dryness of the skin, which form a constant symptom of the peripheral feature. As in causalgia, one frequently sees



trophic troubles concerning nails, hair or skin and even spontaneous blisters.

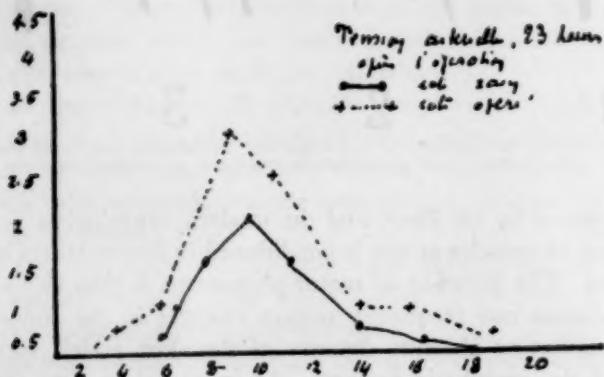
Sometimes repeated pressure produces sloughs on limbs whose sympathetic functions are disturbed by a traumatism or amputation.

Other vasomotor phenomena are cyanosis, local blue oedema or large white oedema reaching the origin of the limb without any signs of phlebitis or arterial obliteration. Pains and muscular atrophy may accompany these

symptoms as well after deep contusions of the tip of the limb as in small traumatisms.

All these apparently different symptoms have one common point: they are but the manifestation of a circulatory change, vessels being not injured, none of the apparatus concerning them is touched, nor the sensory, the muscular systems, or glands or skin. And as all are more or less connected, there is evidently a common origin.

This may not be found in the cerebrospinal nervous system as there is no systematized topography. It is neither in the vascular apparatus which is anatomically healthy; operations on the vasomotor system seem to prove that their origin is to be found in the sympathetic innervation. In some cases



there is anatopathological proof: The artery holds more than usually to the common sheath of the vessels by sclerous adhesions, and the external layer of the artery is more vascularized. The artery presents a particular aspect, being striped in a parallel way by very fine vessels. I have found these lesions with paroxysmal pains in chronic arteritis, in painful stumps and in trophic troubles. But one must acknowledge that in most cases one cannot find any anatomical change explaining the vasomotor ataxy, for our knowledge on the anatopathological features is still very imperfect.

Another explanation of the syndrome might be given: Sometimes when there is a defective vasomotor innervation the causal injury (bruise, fracture, scar) is often distant from the vessels, at the periphery, in a richly furnished zone of sensitive innervation and the vasomotor disturbances seem due to an ortho- or antidromic reflex, starting from the injured point, the way back being the peri-arterial sympathetics.

This is explained by the fact that at the beginning of the accidents the sympathetic irritation may be sufficiently intense to bring forth spasm and fatal ischaemia in limited parts of the tissues. Thus are produced the local gangrene of Raynaud's disease or after certain prolonged pressure Volkmann's syndrome symptomatic of local muscular necrosis.

THE PERI-ARTERIAL SYMPATHETICS

Is it not the proof that modified circulation is the real cause of all the phenomena studied above?

III. This leads one to believe that logically the treatment of those vasomotor or trophic troubles must aim to modify peripheric circulation by peri-arterial sympathectomy. The technic is to isolate the artery on 8 to 10 cm., to fix the vascular sheath after dividing, to hold one part with a forceps and dissect off the cellular tissue either with knife or cannular sound until there has been effected complete denudation of the vessel, which becomes greatly reduced in size. This brings no injury to the arterial wall. I verified this fact twice at four and eight months' interval.

I have performed this operation sixty-four times: In eleven cases of causalgia or equivalent syndromes; two cases of painful stumps; nineteen cases of post-traumatic contractures; four cases of large post-traumatic oedemas; one case of trophoedema; four cases of ischaemic sequels; one case of trophic sloughs on a stump; ten cases of trophic sloughs after nervous section; one case of trophic slough of the heel after medullary injury; one case of varicose eczema; one case of trophic troubles after frostbite; one case of spasmodic paralysis; three cases of an attempt to modify tension of cerebrospinal fluid; two cases of Jackson's epilepsy; one case of goiter; one case of intermittent claudication; one case of erythromelalgia.

I obtained remarkable successes and had complete failures. Operation failed in the case of intermittent claudication; in one case of trophic troubles after frostbite, in one case of spasmodic paralysis, and in certain cases of painful syndromes like erythromelalgia.

These failures are easily explained by the fact that the syndrome's nature is still unknown. Sympathectomy was performed, but as an attempt after numerous therapeutical trials. These failures, however, must not discourage, because their analysis may permit one to class in different groups seemingly alike facts and to enlighten some syndromes still obscure. This discussion shows the impossibility of delimiting yet exactly the indications of sympathectomy. I only want to give the results of five years' personal experience.

1. *In painful phenomena* sympathectomy is often very efficacious. In causalgia after war wounds it gave me in nine cases two complete failures, two satisfying improvements, and five excellent results, two of them being noted for several years. Platon has published a series of twelve cases, all seen again after more or less long intervals. He obtained 75 per cent. of successes. In certain painful crises preceding gangrene caused by obliterant endarteritis with or without intermittent claudication it has given the same good results as in painful acroparästhetic syndromes consecutive to bruise of finger, to wounds of hand, palm or footsole. Sympathectomy is thus worth trying in these cases.

It was twice performed for Raynaud's disease and gave a good result.

The result was less constant in painful stumps where I had one success and one failure. It seems to be efficient where the neuralgia of the stump

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is associated with vasomotor crises, muscular contracture or convulsive cramps. The neurologist, Clovis Vincent, related recently a striking example: In a case of painful stump, both deep general narcosis and the section of the main nerves failed to attenuate the stiffness and the convulsive cramp. Immediately after sympathectomy the muscles relaxed, and forty days after the pains had not reappeared.

2. *Concerning muscular phenomena* only the hypertonic symptom is influenced by sympathectomy. Heitz and myself have seen it in contractions consecutive to war wounds. All eighteen patients were much improved; the day after operation contracture ceased and voluntary movements became possible. In some very serious cases, only sympathectomy permitted the motor reeducation. I do not believe one can improve by sympathectomy what is wrongly called Volkmann's ischaemic paralysis. Whatever may be its starting-point, the syndrome is the consequence of a muscle's focal necrosis; it is a definitive lesion that nothing can modify.

In three personal cases of trophœdema a rapid diminution of the oedema was obtained.

3. *In trophic troubles leading to ulcers, sympathectomy is very efficacious:* twelve cases out of thirteen were followed by rapid healing, but relapse is possible if the cause of the trophic trouble has not been removed, and the cause is not always removed by the sympathectomy.

This is the case in perforating ulcers which never were operated successfully. Therefore after my experience I should not advise it. Sympathectomy also failed in a case of numerous ulcerations consecutive to frostbite. The initial lesions, neuritis or arteritis, provoked relapse of the ulcers.

4. *In cases of trophic symptoms after nerve sections results were excellent.* In ten patients I obtained rapid healing of the ulcers by sympathectomy. However, after observing seventeen cases, I believe sympathectomy should be replaced here by the removal of the neuroma of the sectioned nerve, which is the starting-point of vasomotor reflexes causing the trophic trouble. The removal of the neuroma must be followed by the reconstitution of the nerve's continuity either by suture or by grafts, avoiding thus the relapse of the neuroma. I performed seven grafts with complete satisfaction and now prefer this method to sympathectomy in spite of its satisfactory results.

What is the real action of sympathectomy? How does it realize healing of the most desperate ulcers? This seems to me due only to local circulatory hyperactivity noted always after sympathectomy in the following hours, vasodilatation being apparently one of the most active causes in the tissue's growth; certain local giantisms observed during growth depend probably on constant vasodilatation. After sympathectomy, vasodilatation accompanies local elevation of temperature and of pressure, both favoring healing. This fact is experimentally proved in the following way: Having produced vasodilatation in a rabbit's ear by removal of the superior cervical ganglion, one makes on both ears a wound of equal size. The sympathetized side is

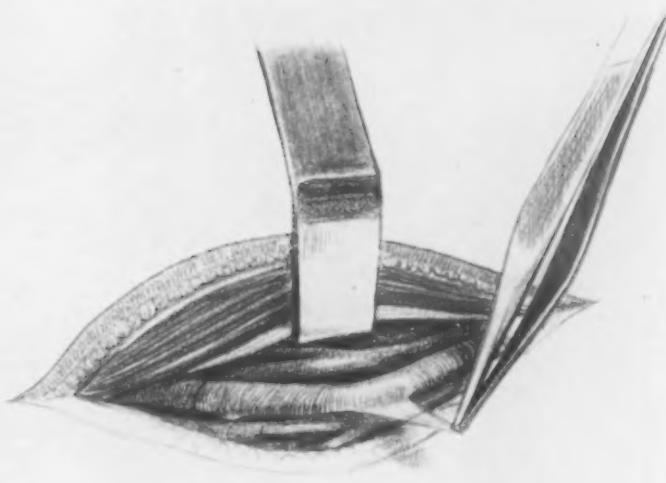


FIG. 4.—The forceps catches a fold of the arterial external layer and holds it out of the wound.
(1) In both figures the thickness of the external layer has been exaggerated to elucidate the demonstration. Drawings by Dr. P. Bonnet, associate professor of surgery in Lyons.

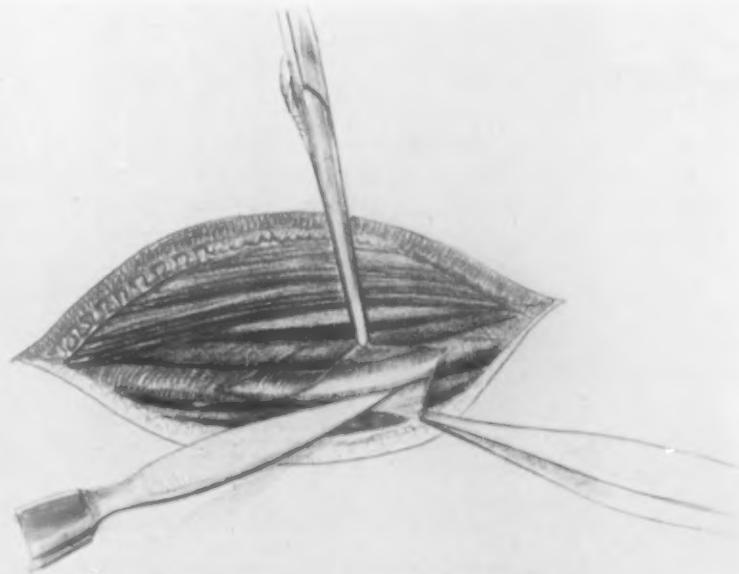


FIG 5.—The knife opens this fold and softly decorticates the artery.

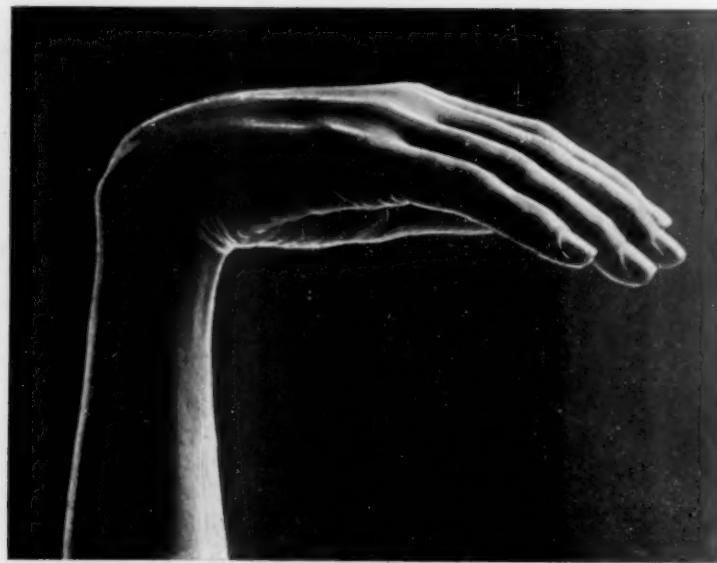


FIG. 6.A.—Contracture of the fingers after injury of the forearm.



FIG. 6.B.—Contracture of the fingers after injury of the forearm—periarterial sympathectomy. Result after three days.



FIG. 7.—Contracture of the fingers after injury of the forearm—peri-arterial sympathectomy. Result after six days.

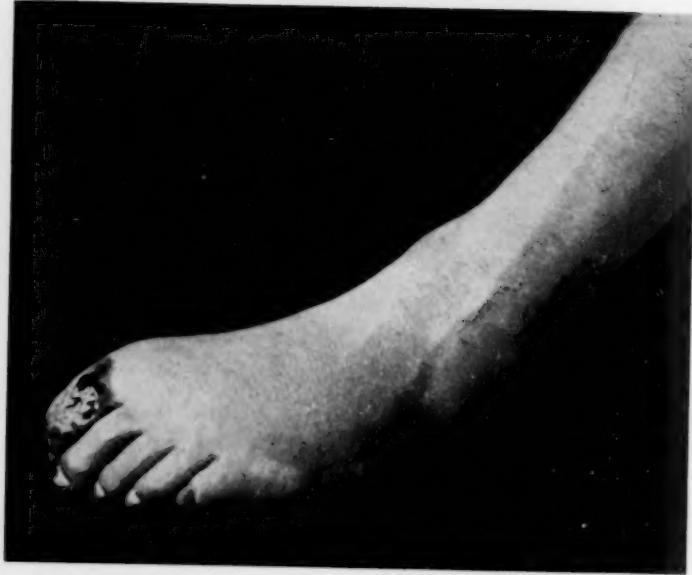


FIG. 8.A.—Trophic ulcer of the first toe after section of the sciatic nerve.

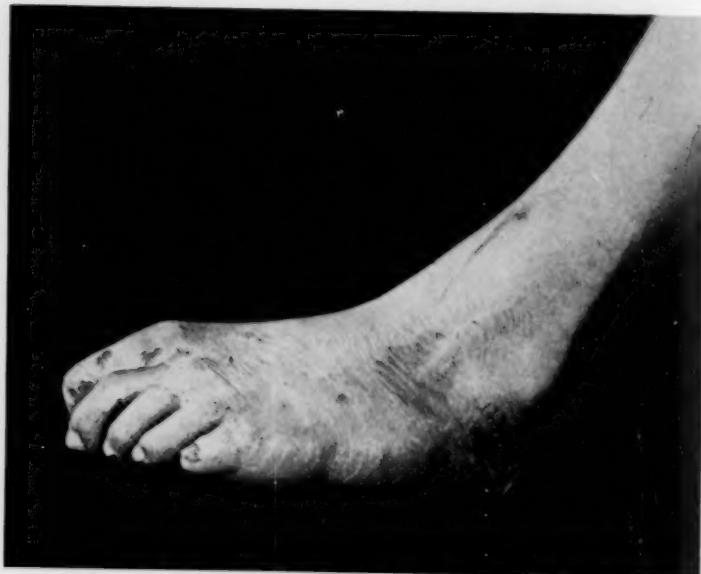


FIG. 8.B.—Trophic ulcer of the first toe after section of the sciatic nerve.
Recovery eight days after peri-arterial sympathectomy.



FIG. 9.A.—Spontaneous ulcer of stump with vasomotor troubles.



FIG. 9.B.—Spontaneous ulcer of stump with vasomotor troubles. Healed by peri-arterial sympathectomy.



THE PERI-ARTERIAL SYMPATHETICS

more abundantly bleeding and more intensively red colored. Four days later its wound is covered with granulations, epidermis begins to grow, while on the opposite side the wound remains gray-colored without any epidermic border. On the eighth day there is complete healing on the sympathectomized side, while on the other side healing extends only over half the wound. A fortnight later the scar of the vasodilated side is more regular and supple, of better quality than the other and shows no retraction.

Peri-arterial sympathectomy has identical effects. Healing of trophic troubles is thus a question of vasodilatation, and therefore peri-arterial sympathectomy must be tried in these cases. The characteristic of sympathectomy is to be more vascular than a nerve operation. For this reason its consecutive vascular reactions might perhaps be employed in many circumstances. Producing an immediate ischaemia, lasting eight or ten hours, one can perform it to insure preventive haemostasis. I did it successfully in three brain operations. On the other hand, the post-operative vasodilatation being lasting, it could be utilized to help the insufficient circulation, for instance, in obliterant endarteritis, or to prepare the reestablishment of cerebral circulation previously to ligature of the common carotid. Therefore in spite of the hypothetic character of it I must believe the question ought to be studied concerning the viscera and glands. I wonder if the possibility of producing locally active hyperæmia might not give us a new power of action on organs when these are becoming insufficient? Only repeated experimental researches may reveal to us what those suggestions are leading to—they are not yet begun; I offer them to your appreciation.

THE SIMPLIFICATION OF TECHNIQUE IN OPERATIONS FOR HARE-LIP AND CLEFT PALATE*

By JAMES E. THOMPSON, M.D.
OF GALVESTON, TEXAS

THE object of the following communication is to explain in a concise manner the anatomical faults present in hare-lip and cleft palate and to formulate rules of technic by which the deformed structures can be brought into the position they would have occupied if union of the component parts of the face and palate had occurred at the proper time, that is about the seventh week of intra-uterine life.

We have never been able to explain why the edges of the embryonic fissures of the face and palate fail to unite. There is no reason to believe that the failure is due to lack of development of the lateral halves of the palate or of the alveolar border, because in almost all cases careful measurements taken soon after birth show that the superficial area of the lateral processes is quite sufficient to complete the roof of the mouth, if the maxillæ could be approximated and the palatal plates changed from their vertical to a horizontal position.

The moment embryonic fusion fails, the great and probably the only agent in preventing subsequent union is the tongue, which exerts constant pressure between the edges of the cleft until it succeeds not only in prying the jaws apart, but in pushing the palatal plates upwards until they come to occupy a somewhat vertical position. The mechanism of this disrupting force can be clearly traced in every case. Whenever the gap is large enough for the tongue to be inserted, evidences of muscular pressure are always present and the direction in which the disrupted parts are moved is always that of the tongue thrust, *i.e.*, from behind forwards and from below upwards. Since the force exerted by the tongue is greatest at the tip and decreases gradually as we pass backwards toward the epiglottis where it reaches its minimum, we should expect to find the deformity greatest where the prying force of the tongue can be exerted to greatest advantage. The expectation is supported by the actual findings. Thus in clefts confined to the soft palate the muscular action of the posterior part of the tongue is so feeble and so ineffective as to be negligible. The slight disrupting force exerted is more than neutralized by the mobility of the muscular halves of the velum. The deformity is consequently very slight. On the other hand, in clefts extending through both soft and hard palate but stopping short at the alveolar margin, the tongue exerts considerable force on the lateral palatal plates of the maxillæ, forcing them upwards and outwards against the lateral walls of the nose and producing an unusually wide cleft. In addition the anterior and

* Read before the American Surgical Association, June 16, 1921.

OPERATIONS FOR HARE-LIP AND CLEFT PALATE

lateral portions of the alveolar ring are also pushed outwards to a considerable extent. But the severest degrees of deformity occur in examples of complete palatal cleft extending through the alveolar margin into the nostril. The tongue has full play and acts like a wedge driving the maxillæ apart in front so that they swing outwards like double doors on hinges which are situated behind near the posterior ends of the alveolar borders.

The principles of treatment are founded on accurate knowledge of the anatomy of the deformity; in other words, on a correct estimate of the degree of distortion. This can be measured graphically by comparing the deformed alveolar border with one reconstructed from a mold taken of the alveolar border of the mandible of the patient. In using mandibular measurements as a standard we must not forget that under normal conditions the articulation of the mandible is a little outside that of the maxillæ. (See Fig. 3.) Therefore the maxillæ must be molded until the alveolar ring is a little smaller than that of the mandible.

For our purposes it will simplify matters to base the principles of treatment on an analysis of the anatomical features of a few selected common types of deformity. In this way we shall avoid unnecessary detail. To this end we have selected three types:

1. Complete unilateral cleft of the lip, unilateral cleft of the alveolar border and complete cleft of the palate.
2. Complete bilateral cleft of the lip, bilateral cleft of the alveolar border and complete cleft of the palate.
3. Intact lip, intact alveolar border and complete cleft of the palate.

Type 1.—*Complete unilateral hare-lip associated with a cleft extending through the alveolar border of the jaw and through both hard and soft palate.*

Fig. 1 illustrates the text. It is a life size tracing of a plaster model of a typical case of this variety of cleft. (See also Fig. 6.)

The points marked B and B' represent the anterior ends of the alveolar borders of the maxillæ and are placed on parts that would be in contact if the jaws had united. The distance B to B' varies within great limits. It is often as much as fifteen millimetres across. The points marked A and A' are on the alveolar border at the site of their most pronounced lateral bend. The distance A to A' indicates the greatest transverse measurement and it is always greater than it would be if the maxillæ had united. By comparing it with the corresponding measurement across the mandible an accurate estimate can be formed as to the distance the two halves of the upper jaw have been thrust apart. We have found in average cases that the measurement is several millimetres greater than it would be in a normal palate. The points C and C' mark the posterior end of the alveolar ridge. For all practical purposes this indicates the locality where the maxilla and palate bones are connected. The X represents the position of the hamular process of the pterygoid. The distance CC' is seldom increased materially. On an average the increase will not be more than one or two millimetres. The side which carries the premaxilla (the larger one marked E in the figure) always receives the full force of the tongue thrust, and in consequence its anterior end B is pushed outwards and forwards. The smaller side (E') receives very little

tongue thrust and consequently its position is changed very slightly. As a rule its alveolar border articulates fairly accurately with that of the mandible.

The lateral palatal plates deserve careful scrutiny. The mucous membrane covering each plate consists of two distinct areas, a lateral which forms a strip running along the alveolar border which is thick, rough and corrugated, and a median bordering on the cleft which is thin and smooth. The larger lateral plate (E) usually fuses with the septum. When the septal attachment is complete the nasal cavity on this side is closed off as far back as the junction of hard and soft palate. It is usually well formed and roomy, but in some instances where tongue pressure has been excessive both lateral palatal process and septum are crowded outwards, the result being that the lower portion of the septum is bent into a somewhat horizontal position near its lower attachment, and the nasal passage on this side is considerably narrowed. The smaller lateral plate E' has no attachment to the septum. As a rule it lies somewhat vertically with its free edge pointing upwards, having been pushed upwards by tongue pressure. A study of Fig. 2 A and B (a coronal section of upper and lower jaws of a seven months' foetus with cleft palate) shows most of the points emphasized in the above description. The effects of the tongue thrust on the lateral palatal plates and septum are particularly evident. The smaller palatal plate is almost vertical and its free edge is opposite the septum at a point fully 2 mm. higher than the attachment of that process to the other palatal plate. Its cranial surface has been squeezed against the turbinated bones of this side. The larger lateral plate is pushed upwards to a slight extent only, because the septum has acted as a buttress to protect it from pressure. The lower portion of the septum has been molded into a somewhat horizontal or slanting position.

After a careful study of a large number of models of this type of deformity the following conclusions seem to be justified:

Firstly: If embryonic union fails, the resulting deformity seen at birth can be accounted for in every detail by the muscular action of the tongue.

Secondly: That there is little or no separation of the posterior ends of the maxillæ from one another, and that any movement here is in the nature of a hinge movement by which the posterior end of the maxilla and the vertical plate of the palate bone swing on their attachments to the pterygoid processes of the sphenoid.

Thirdly: That the side to which the premaxilla and the septum are attached (the larger side) is more affected by the tongue thrust than the other maxilla, the result being that its anterior end (B) swings outwards and forwards on its hinge (situated behind at C), taking with it the septum and nose and carrying the alveolar border to a plane far outside and in front of its normal position, and further, that the attachment of the septum to the palatal plate has enabled it to withstand the vertical thrust of the tongue and to retain a reasonably good horizontal position.

Fourthly: That the other maxilla (smaller side) is displaced as a whole very slightly in a lateral direction, but that its horizontal palatal plate is seriously deformed, being frequently thrust upwards into a vertical position against the turbinate bones.

It is evident from the preceding description that the exact measure of the separation of the maxillæ from one another can be obtained from measure-

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ments taken between corresponding points on opposite sides of the alveolar borders and comparing them with corresponding measurements taken across the semicircle of the alveolar border of the mandible. We have found that the measurement CC' is seldom greater than a similar measurement across the mandible. In an average case the measurement AA' is usually 2, or at most, 3 millimetres greater than normal. The distance BB' varies within great limits. It is often 10 and sometimes 15 millimetres in length. The statement made by Brophy and others that the width of the cleft is the true measurement of the extent of separation of the maxillæ is not supported by facts.[†] It can be true only in instances (very rare) in which the lateral maxillary processes have retained their normal horizontal position. When the lateral processes are driven into a vertical position (the greater majority) the edges of the cleft are carried with them and this factor increases the width of the cleft. As a matter of fact the true estimate of the width of the cleft is obtained by taking the sum of two displacements (1) the lateral displacement of each maxilla and (2) the vertical deviation or slant of the lateral palatal plate. From descriptions of Brophy's operations the impression is given that the edges of the cleft can be brought into contact by merely approximating the sides of the maxillæ. A glance at Fig. 2 (left) will show the fallacy of this idea. Approximation of the maxillæ would bring the edge of the smaller (right) vertical palatal process against the side of the septum but could never bring it in contact with the edge of the opposite palatal process. Contact of the edges of the cleft can be secured by mere approximation under two conditions only: (1) in the rare cases where the palatal plates have retained the normal horizontal position, and (2) in cases where the palatal plates have been thrust symmetrically apart. The latter condition is seen in most cases of complete cleft palate with a free septum. A little reflection, however, will convince us that approximation in the latter condition would be inadvisable, and if persisted in would result in serious disfigurement because the jaw would be narrowed to such a degree that a long, narrow beak would result.

Type 2.—*Complete double hare-lip; bilateral cleft through the alveolar border; complete median cleft through both hard and soft palate.*

Fig. 9 is a life size sketch of a plaster mold of a typical example of this deformity.

[†] "I have found that the upper jaw in comparison with the lower is just as much broader than it should be as is the distance between the borders of the fissures."—Brophy's Oral Surgery, p. 580.

"The upper jaw is just as much wider than it should be as the distance between the borders of the cleft."—Brophy's Oral Surgery, p. 593.

"In complete cleft palate the maxillary bones have failed to coalesce and are separated from each other by the width of the cleft. Theoretically, therefore, the approximation of these bones should bring together the edges of the cleft."—Berry and Legg, Hare-lip and Cleft Palate, p. 261.

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The septum is massive. It hangs downward like a ploughshare and is unattached to either lateral maxillary plate. It shows a bend to the right along its whole length. Its anterior end is elongated and projects in front of the anterior ends of the maxillæ. The premaxilla is attached to the front of the septum. It forms a massive projection distinctly divided into two prominent globular swellings which contain the unerupted central incisor teeth. A small erupted tooth which represents an accessory incisor is shown attached to the lateral aspect of the right globular process. (The position of the premaxilla and the unusual length of the septum suggest excessive growth. In reality the increased length of the septum is produced by the molding and stretching of the soft bone at its anterior end by the pressure of the tongue on the globular process. Not infrequently this process assumes a horizontal position, and seems to project from the tip of the nose, the columella being almost obliterated.) Both maxillary processes are symmetrically placed as to each other, but careful scrutiny shows that the left process has suffered more from tongue pressure than the right, in that the anterior end of the alveolar process has been pushed a little further outward and the palatal plate a little higher. The *right maxillary process* E is separated from the globular process and the anterior end of the septum by a narrow fissure, about one millimetre wide. Its alveolar margin curves round in front of the palatal plate and forms the margin of the fissure between it and the globular process. The palatal plate is well developed and shows little upward displacement. The rugose and smooth areas of mucous membrane are normally distributed. The *left maxillary process* E' is separated in front from the globular process by a distance of three millimetres and from the edge of the septum by a distance varying from five to seven millimetres. The alveolar border does not curve around the front of the palatal plate. The palatal plate occupies a higher level than that of the right side. On careful inspection it is found that the part of the palatal plate covered by rugose mucous membrane lies in its normal horizontal position, while that covered by smooth mucous membrane is vertically placed. The free edge of the cleft on this side is almost two millimetres higher than that on the right. It is evident, here, that the tongue has exerted its greatest pressure in the angle formed by the junction of septum and premaxilla and in the space between these parts and the front of the left maxillary process, and that the effect has been to thrust the maxillæ apart and to force the premaxilla forward. The measurement CC' taken across the space between the posterior end of the alveolar margin was about three millimetres greater than that across the ends of the mandible. The other measurements AA' and BB' were more difficult to fix accurately because it was next to impossible to indicate with absolute certainty corresponding points on maxilla and mandible. By comparing outlines of the superimposed molds of the alveolar border of upper and lower jaw (Fig. 10) the extent of the deformity is shown in a graphic manner. From this we computed that the measurement AA' was nine mm. and CC' three mm. greater than normal. For practical purposes we can assume that the maxillæ have been pushed apart a distance of three mm. behind, at CC', a distance of nine mm. in the middle at AA' and at least nine mm. in front at BB'. (The actual measurements of this specimen are given in detail on page 28.)

Type 3.—*Complete cleft of the palate with intact alveolar border and lip.*

Fig. 13 is a life size sketch of a plaster mold of a typical example of this deformity. The alveolar border is frequently well formed and seems apparently undeformed. If, however, careful measurements are taken and compared with those of the lower jaw, it will be found that the greater part of the circumference of the alveolar ring of the upper jaw is expanded. The expansion affects the

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middle and anterior parts of the semicircle almost entirely. As a result the lower jaw articulates well within the ring of the upper and the chin recedes. The palatal plates are often pushed into an exaggerated vertical position and as a result the edges of the cleft are placed high up in the nasal cavity and the cleft is unusually wide. This is more evident in cases where the cleft extends as far forward as the premaxilla. In the case figured the whole length of vomer stands out in relief and hangs free in the middle of the cleft. On either side of it there is a deep recess the lateral walls of which are formed by the palatal plates of the maxillæ, which have been thrust into a vertical position. The smooth area of mucous membrane is not shown in the drawing because it was out of perspective. The rugose area is well in view.

It is not necessary for our purpose to describe the anatomical features of all the numerous varieties of fissure in the lip, which are associated with the types of bony deformity which we have just described. Most of the standard operations commonly used will give excellent cosmetic results if attention is paid to the basic principles of plastic surgery and the bony deformity is corrected. We must, however, insist that correction of the bony deformity ought to precede every operation, because it is impossible to repair a lip that will satisfy critical inspection unless we have previously restored the curve of the alveolar border of the jaw, straightened the nasal septum and refashioned the anterior nasal aperture. The only way to remedy a flattened slit like ala nasi is to straighten the nose by restoring the pyriform aperture of the nasal cavity. A full prominent lip can be obtained only by restoring the curve of the alveolar border, which then serves as a cushion for the lip to rest upon. Once the bony deformities are remedied the repair of the lip and nostril is a matter of detail the principles of which can be enunciated under the following heads: (1) The fashioning of the nostrils. (2) The making of a lip of proper depth. (3) Restoration of the vermillion border and the red line of the lip.

1. *The fashioning of the nostrils.* Developmentally the margin of the nostril is formed by the union of the lateral and medial nasal processes both of which belong to the premaxilla. Cases of hare-lip are occasionally seen where the lip is cleft almost into the nostril, but the ring of the nostril is completed below by a narrow strip of skin of a triangular shape attached by its apex to the side of the columella. Fig. 4B shows this developmental abnormality. In Fig. 4A we see the lines of embryonic fusion along which defects may occur. Clefts in the lip proper are always due to failure of union between the maxilla and premaxilla. If we examine carefully the margin of the nostril in a case of complete cleft we will find the following appearances. On the surface of the lip just medial to the projection which forms the ala nasi there is a smooth area of lip which ends abruptly in a hump which forms the corner between the cleft and the nostril margin. This surface represents the triangular strip which belongs to the lateral nasal process. The hump represents the point which should be attached under normal conditions to the side of the columella. On the medial side of the

cleft, extending from the columnella there is a similar smooth area which occasionally (but more rarely) shows a similar hump or projection. If the hump on the outer horn of the nostril be brought in contact with that (or the area) on the inner horn, it will be found that the ring of the nostril will be restored. If a measurement is taken of the circumference of the sound nostril and that of the nostril restored, in this manner they will usually coincide. If there is any difference it will be caused by the difficulty in fixing the point on the median side (columella) to which the projection on the lateral side is opposed, because quite frequently the projection is wanting on the former. If there is no projection on the median side of the columella, we bring the projection on the lateral corner of the cleft over to the side of the columella until the circumference of the nostril is restored accurately. We then fix this point indelibly by transfixing it with a horsehair stitch. We then have the two corners of the horn fixed, and if care is taken not to shave them when the sides of the cleft are being pared, the restoration of the nostril will be perfect. If these details are carried out scrupulously the ala nasi will be carried into the position it ought to occupy; *i.e.*, it will be carried medially and upward, and its natural curve restored. Careful comparison with the sound nostril is necessary.

2. *Making a lip of the proper depth.* In cases of single hare-lip, the exact depth of the lip required can be determined accurately by measuring on the sound side, directly downward from the lower margin of the nostril to the mucocutaneous margin. Screw compasses with sharp points are used for this purpose. We then measure the same distance from the hump or projection (or suture), previously fixed at the margin of the nostril, to the mucocutaneous junction on either side of the cleft and fix the place indelibly by a prick of the point of the compasses. This measurement fixes the length of the lateral incisions required to make the lip deep enough when the sides of the cleft are pared and brought together.

3. *Restoration of the vermillion border of the lip so that the mucocutaneous junction runs continuously from side to side without a break and the mucous membrane is of the proper depth.* Approximation of the sites of the punctures made at the mucocutaneous junction by the point of the compasses after the edges of the cleft have been pared, will restore the red line of the lip accurately. Proper depth of mucous membrane is obtained by measuring from the mucocutaneous puncture to a point on the free margin of the lip, near the corner of the cleft, a distance a little greater than the vertical depth of the mucous membrane immediately below the puncture. This point is fixed by pricking with the compasses. A similar point is fixed on the opposite side of the cleft. We have then fixed definitely by measurements three points on each side of the cleft, one at the upper corner of the cleft, another at the mucocutaneous junction and the third at the free edge of the lip. The lip is now transfixed by a cataract knife at the point on the mucocutaneous junction. From this point it is carried upward with a

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slight outward curve and cuts its way into the cleft just median to the hump (or puncture) at the margin of the nostril. The mucous membrane of the lip is then divided by an incision which passes from the puncture on its free margin to the point of transfixion. The procedure is then repeated on the opposite side of the cleft. This produces two lines of incision apposed to one another that will coincide accurately if the points previously marked are brought into contact. The steps of this procedure are shown in Fig. 5 (1, 2, 3 and 4).

The foregoing description applies to cases of single hare-lip. Double hare-lip requires special consideration. The area of lip attached to the premaxilla which under normal conditions forms the philtrum is usually very small. Quite frequently it forms a small projection with a free semicircular border attached to the end of a short, poorly formed columella. It appears to stick out from the end of the nose. It can rarely be used, as was the developmental intent, to make the whole depth of the new lip, because it is too short to cover the alveolar border of the premaxilla, much less the incisor teeth after eruption. It is therefore used to form the upper medial portion only of the new lip. The lower part is formed by bringing the lateral (maxillary) portions of the lip together in the middle line below the philtrum. From an embryological point of view the method is imperfect because the central portion (or philtrum) of the new lip is not obtained exclusively from the premaxillary covering. The usual way in which the soft parts are approximated is the following: The premaxillary lip is carefully pared either into a triangular or semicircular form by removing all the mucous membrane from nasal corner to nasal corner. Then the lateral margins of the cleft are pared according to the rules previously laid down. Care is taken that the distance AB must always be greater than the distance ED, otherwise when the parts are brought together the point D would lie between B and B' and would break the line of the vermillion border of the lip. It is very seldom that the central part of the lip is deep enough to necessitate such precaution. The steps of the procedure are shown in Fig. 5 (5 and 6).

(The above description is a modification of that previously described by the author in *Surgery, Gynecology and Obstetrics*, May, 1912, pp. 494 to 505.) Results of the operations are shown in Figs. 25, 26, 27 and 28.

Now we are in a position to trace step by step the operative procedures required to restore the jaws, lip and palate as closely as possible to their normal state.

For many years it has been my aim to finish the work at as early an age as possible, because I felt sure that the chances of normal speech would be favored if the palate could be closed before the child learned how to talk. It has been my custom for many years to operate on the lip and alveolar border as soon after birth as possible. I have postponed the operation on the palate to a much later date for two reasons: First, because very early operations on the palate are attended by a high mortality, and secondly, because the

operation is easier to perform when the baby is older. After the age of six months most well-nourished babies are strong enough to undergo palate operations and there is comparatively little danger to life if the operations are short in duration and attended by slight loss of blood. In one case of unilateral complete cleft of the lip, associated with cleft of the alveolar border and complete cleft of the palate, repair of lip and palate was completed when the baby was five months old. This is the earliest date in my series (Case II, J. H. Second alternative). The next earliest case was six months old at the time of the operation on the palate (Case I, M. R. First alternative). Both were favorable cases. The babies were exceptionally robust and the clefts were narrow. In the great majority of cases we are fortunate if we can complete the closure of the palate before the child begins to talk. Even under the most favorable conditions, for one reason or another, the babies will be a year or eighteen months old before the work can be completed. Double hare-lip, associated with complete cleft of the

TABLE

Operation.	First alternative.	Second alternative.	Third alternative.	Fourth alternative.
First	Lip and alveolar border	Lip, alveolar border and anterior part of palate	Alveolar border and anterior part of palate	Alveolar border
Second	Palate Complete at one sitting (rare) or anterior part only	Palate Posterior part	Lip	Lip
Third	Palate Posterior part		Palate Posterior part	Palate Complete at one sitting (rare) or anterior part only
Fourth				Palate Posterior part

alveolar border and complete cleft of the palate, stands in a class by itself, and complete closure of these palates is rarely possible before the end of the second year.

The types of deformity described previously will now be taken in order and each stage of the reconstructive process taken up step by step.

Type 1.—*Complete unilateral hare-lip, unilateral cleft of the alveolar border and complete cleft of the hard and soft palate.*

Occasionally when the cleft is narrow reconstruction can be completed in two stages. Usually three operations are needed and in a few cases four. Each case is a law unto itself. The sequence of the operative stages is determined by the nature of the first operation and the extent of reconstruction accomplished at this time. The attached table shows in a graphic manner the complete dependence of each subsequent operation on the first. It is an accurate mirror of my own practice. In the text the scheme will be followed as closely as possible.

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In my earlier work I followed the operative sequence given in the "*first alternative*" and found that the results were very satisfactory. There was, however, one serious objection. In the second operation it was very difficult to repair the extreme anterior end of the cleft in the hard palate, and as a result a small opening persisted that was very hard to close. This led us to try the "*second alternative*," in which we were ambitious enough to try to repair alveolar border, anterior part of hard palate and lip in one sitting. We found that the results were satisfactory and that the palate could be closed subsequently in one operation. Unfortunately, the operation was followed by severe shock and was unsafe unless the baby was unusually well nourished and robust. This led us to employ the "*third alternative*," in which alveolar border and anterior part of palate were repaired at the first operation and the lip and posterior part of the palate at later and separate operations. As our experience grows we are gradually adopting this procedure as the one of choice, reserving the first alternative to those cases where we wish to gratify the desire of the parents to have the lip closed as soon as possible. The "*fourth alternative*" is rarely employed in unilateral clefts of the alveolar border. It is reserved almost exclusively for bilateral clefts of Type II.

We shall now proceed to describe step by step the operations included under the heading of the "*first alternative*."

FIRST ALTERNATIVE

FIRST OPERATION—REPAIR OF ALVEOLAR BORDER OF LIP

The first step is to separate the lips and cheek from the underlying maxillæ over the greater part of their outer surface. Bleeding will be slight if the soft parts are pushed from the bones by sponge pressure after the mucous membrane is divided. Then the maxillæ are pushed together by thumb pressure exerted on the prominent maxillary process. Referring to Fig. 6, pressure is applied to the body of the maxilla in the direction of the arrow and the bone is pushed over until the distance AA' is reduced to its proper corrected length. The line of pressure is changed, passing forward gradually toward the point B, until the ends of the alveolar margins B and B' are brought into contact. Care must be taken to mold the body of the jaw and not the alveolar processes, otherwise they may bend inward and the body of the jaw may remain in its original position. The molding must be done thoroughly and we must not desist until most of the resiliency of the jaw has been overcome and the points B and B' show little tendency to spring apart. In children over three months of age digital molding alone may be impossible and it may be necessary first to divide the body of the jaw by a transverse cut either by a knife or by a chisel. The line of incision in the bone should be just below the malar buttress of the maxilla and it must always be above the sockets of the teeth. Afterwards the parts are molded and brought together. Molding of the smaller side of the maxilla is seldom necessary because its lateral displacement is slight. The coapted maxillæ are now fastened together. For several years I have been using kangaroo tendon to hold the bones in place. The mucous membrane is removed from the ends of the alveolar borders at B and B'. In doing this thoroughly we sometimes open the socket of a tooth, which necessitates its removal. A drill is passed through the body of each maxilla, entering

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on its outer surface above the sockets of the teeth and well behind the pyriform aperture of the nose. It enters the nasal cavity above the horizontal palatal plate. Along the track of the drill an Emmet needle is passed carrying a silk thread, which is used in turn to pull a strong strand of kangaroo tendon along the track. The maxillæ are finally brought close together and the tendon knotted in front. If care is taken perfect approximation is secured. At this stage of the operation it will be found that the nose is straightened, the pyriform aperture of nose restored and the sides of the alveolar border approximated. The margins of the cleft in the lip now lie quite close to one another. If the child's condition is good it is our custom to repair the lip at once. The edges of the cleft are pared and the operation is completed according to the technic described previously.

The results following the use of kangaroo tendon have been very satisfactory. It has failed me in one case only, and the reasons for this were probably twofold, *viz.*, (1) inadequate molding of the maxillæ, (2) the use of a strand of tendon too thin to stand the strain. It is absolutely necessary to mold until the resilience of the bone is completely overcome, otherwise the kangaroo tendon will not stand the strain. If resilience cannot be destroyed it is far safer to fasten the bones together with silver wire, either with or without the use of lead plates. As a matter of fact, the only reason for using kangaroo tendon is that it enables us to close the lip at the same sitting without the worry of contemplating the subsequent removal of a silver wire from underneath the freshly united lip. In all two-stage operations on the alveolar border and lip silver wire is preferable and safer.

SECOND OPERATION—REPAIR OF THE PALATE

We allow a period of from four to six months to elapse between the operation on the lip and alveolar border and that on the palate. At this time we find that the palate is fairly accessible and that the lip will stretch to any reasonable extent. In favorable cases the palate can be repaired in one sitting. In the great majority two separate operations are required.

1. Complete repair in one sitting.

A tension stitch is passed on each side through the whole thickness of the anterior part of the soft palate. These stitches are retained until both soft and hard palates are completely mobilized. They are used exclusively as tractors and their employment reduces the handling and injury of the palate to a minimum. The mucoperiosteum of the hard palate is now divided down to bone by an incision (Langenbeck's) close to and parallel with the alveolar border. The incision should be about a centimetre in length and should not endanger either the anterior or posterior palatine arteries. Through this incision the mucoperiosteal layer is separated by an elevator from the bony palatal plate over its whole area of attachment, from front to back and from the alveolar margin to the edge of the cleft. The separation from the edge of the cleft can usually be done by the elevator, aided by occasional snips from sharply curved scissors. On the side of the maxilla to which the septum is attached care must be taken to avoid separating the mucous membrane from the side of the septum unless it is the intention to use it as a flap. A lateral incision through the septal and palatal union from front to back can be made with a flat curved knife and this will facilitate the elevation of the palatal flap on this side. Next the attachment of soft palate to the posterior border of hard palate is divided. This (palatal apo-

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neurosis) can be divided best by pulling on the tension stitch, elevating the soft palate and cutting the resisting tissue with curved scissors. At this stage both soft and hard palate can be lifted towards the operator, and if the separation is adequate the flap will lie horizontal in the mouth. The same procedure is repeated on the opposite side. Too much emphasis cannot be laid on the importance of doing this part of the operation thoroughly. No important blood-vessel is imperilled if the directions are followed as described above. At this stage, if the cleft is very narrow, the edges of the palatal flaps can often be brought together without tension; and after being pared they can be fastened together by a special technic (Brophy's plates) with good prospects of primary union. (The essential features of Brophy's method are the following: Two silver wire sutures are passed through the whole thickness of the soft palate on each side, penetrating it near its lateral attachment. The ends of these wires are passed through holes punched in an oblong-shaped lead plate which is trimmed to fit the case. The plate rests on each side on the fleshy part of the velum internal to the hamular process. The edges of the cleft are pared and united by sutures from end to end. Finally the lead plates are adjusted and the silver wires tightened and knotted on each side. Great care must be taken to secure the right degree of tension on the plates. If this method can be carried out, the functional results are much superior to those obtained by the methods to be described later, because the soft palate sustains no injury. Whenever possible Brophy's method should be used. Unfortunately in very young babies conditions are rarely favorable and we are forced to secure complete relaxation by division of the soft tissues. We never hesitate, however, to use metal plates whenever there is any tension on the flaps.) In wider clefts the edges of the palatal flaps cannot be approximated at this stage without tension, and at any hazard this must be avoided. Tension can be lessened by increasing the length of the lateral incision. It can be carried forward a considerable distance without cutting the anterior palatine artery; and, if care is taken to keep very close to the alveolar margin of the jaw and follow its posterior curve accurately, it can be carried backward as far as the level of the hamular process without danger of wounding the descending palatine artery. It is our custom to carry the incision around the posterior margin of the alveolus in a short hook, and then to cut backwards, through mucous membrane only, towards the middle of the tonsil along a line just lateral to the hamular process. The edges of the incision in the mucous membrane gape widely and the palate can be dislocated bodily from the maxilla towards the median line without cutting any of its muscles. If further liberation is necessary division of some of the muscles of the soft palate is unavoidable. We believe that division of the muscles on the anterior surface of the palate is wrong in principle because there is serious risk of wounding the radiating branches of the descending palatine artery if the buccal surface of the palate is incised. The palatal muscles on the posterior or cranial surface of the velum can be divided without this risk. We have found that division of the palato-pharyngeus and levator palati produces complete relaxation. They can be divided safely in the following manner: If the soft palate is elevated by the tension stitch both palato-pharyngeus and levator palati muscles can be brought into view (Figs. 15 and 16). The palato-pharyngeus muscle and the mucous membrane covering it are divided with scissors at a point just behind the middle of the tonsil. By cutting deeply into the lateral wall of the nasal passage with the scissors along a line drawn from the divided palato-pharyngeus to a point just buccal to the orifice of the Eustachian tube the levator palati will be divided. Vigorous elevation of the velum by the tension stitch will put this muscle on the stretch and it will produce a marked elevation under the mucous membrane. Paring of the edges of the flaps is the

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next stage. In the hard palate this is unnecessary if mattress sutures are used; in the soft palate it must be done thoroughly and with the greatest care. The mucous membrane must be removed in a single complete strip to avoid leaving small islands behind. On each side the soft palate is transfixated by a cataract knife and a thin strip of mucous membrane is removed from its free edge extending from the tip of the uvula as far forward as the junction of soft and hard palate.

The last stage is the passing of the sutures. It is often convenient to secure control of each side of the palate by means of tension stitches. Usually we insert three on each side, one in front, another at the junction of hard and soft palate and a third through the thickness of soft palate lateral to the uvula. Blair prefers to handle the palate by means of a tenaculum made by fixing the broken point of a sewing needle in the jaws of a pair of force-pressure forceps. The first suture is passed through both edges of the cleft at the junction of hard and soft palate. This is not tied but is merely used to lift up the flaps and to secure accurate spacing of the rest of the sutures. The sutures are now passed systematically from before backwards. Each stitch is of the mattress type, inserted in such a manner as to avoid strangulating the blood supply to the edges of the flap (vertical mattress stitch, see Fig. 14). Three or four stitches may be required in the hard palate. When tied the raw (upper or cranial) surfaces of the flaps are opposed to one another and the edges of the flaps are turned out like the flange in a water pipe. Similar stitches are passed in the soft palate, care being taken not to penetrate through mucous membrane on its cranial surface. By proceeding systematically from before backwards, and using the last stitch passed as a tractor to hold up the flaps while the next stitch is inserted, little trouble is experienced in placing the sutures in good position. All the stitches are of the mattress variety except those in the uvula, which are of the ordinary through-and-through variety. The suture material varies. For the mattress stitches we have lately been using carefully selected fine silkworm gut. For the other stitches we use horsehair or fine silk.

In Fig. 17 the steps of a palate operation, which was completed in one sitting, are shown. Reconstruction of lip, alveolar border and palate was finished at the age of six months. At the first operation lip and alveolar border were repaired. At the second operation both hard and soft palate were repaired.

2. Repair in two sittings. Cases requiring the two-stage operation must be picked with the greatest care. They bristle with possibilities of failure, and if an unsuccessful operation is attended by sloughing of the flaps subsequent reconstruction may be impossible.

It is a generally accepted fact that a cleft will become proportionally narrower and that the area of available flap will increase as time passes. Many cases with wide clefts and high palatal plates which are quite inoperable in the first year of life pass into the operable class at the end of the second year. Therefore it is wise to wait until measurements of the available tissue show that the operation can be undertaken with a reasonable prospect of success. In these cases it is better to divide the operation into two stages, first closing the hard palate and later the soft. It is impossible to lay down hard and fast rules of procedure because each case must be judged on its own merits. It is better to attempt too little rather than too much and to be content with closing the anterior part of the cleft without inflicting any injury on the velum; because if the velum is rendered hard and cicatricial, the last stage of the operation on the soft palate will be made very difficult and primary union problematical.

The steps of the *first stage* of the operation are essentially the same as those previously described. We always use the liberating side incisions (Langenbeck)

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and lift the mucoperiosteal flaps from the underlying bone very thoroughly. The palatal aponeurosis is divided and each flap is then freed. Of recent years we have made it a point to secure a flap from the side of the septum as shown in Figs. 18 and 19. By this means the area of available flap has been increased materially. The edges of the two flaps are approximated and united by vertical mattress sutures as described previously. The sutures pass backward only as far as the junction of hard and soft palate. The velum is not encroached on in the slightest degree. As a rule union is sure and firm. The stitches very rarely cut out. At the worst, the hind stitch may give way.

The *second stage* is performed two or three months later. It is carried out in every detail as described previously. We find it necessary to make large, liberating side incisions along the old tracks and through these the mucoperiosteum of the reformed hard palate is lifted up once again from its bony attachment and the palatal aponeurosis divided on each side. Not infrequently the side incisions are carried very far back and curved around the posterior end of the alveolar border. At any hazard both hard and soft palate must be lifted up from its bed until it hangs free. Finally the levator palati and palatopharyngeus are divided and tension on the soft palate relieved, after which the edges of the cleft are denuded and the sutures inserted "secundum artem."

Figs. 18 and 19 with the legends attached are typical examples of cases operated on by the "first alternative" followed by two-stage operations on the palate. They are particularly instructive because each one was left with a small hole in the front of the palate just behind the alveolar border. This was closed in Fig. 19, by means of a tongue-flap sliding operation. Final closure of these small holes in front was so troublesome that we cast about for means to avoid the complication. In our first attempts the lip and alveolar border were repaired, and the anterior part of the cleft closed at the same sitting by elevating and sliding across the gap small mucoperiosteal flaps taken from the palatal plates. Such a case is shown in Fig. 20. Suture and adjustment of the flaps was very difficult and subsequent elevation of the mucoperiosteal layer in the later palate operations doubly so. Eventually we were led to use the mucous membrane of the septum in the flap and to formulate the sequence of operations comprised under the "second alternative."

SECOND ALTERNATIVE

In this the first operation aims to mold the jaws, suture the alveolar border, repair the anterior part of the palate and close the lip in one sitting. At a subsequent sitting the remainder of the palate is repaired. The first case on which this procedure was tried was singularly successful. The first operation was followed by very little shock and the results were so satisfactory that reconstruction was completed at the age of five months. Fig. 21 shows the palatal procedures used in this case. In another case, shown in Fig. 22, the operation was successful, apart from a slight failure of union at the junction of hard and soft palate, which necessitated a third operation for its repair.

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The details of the method are as follows: Before the jaws are molded, while the cleft is still wide open, a rectangular flap is reflected from the septum, downward to the margin where the palatal and septal mucosa unite. To secure freedom of this flap the mucoperiosteum is detached over a narrow area from the under surface of the contiguous palatal plate along the whole line of the septal attachment. This flap is carefully held up with tension stitches to avoid bruising. On the other side of the cleft the edge of the mucoperiosteum of the hard palate is raised up along the whole length of its free margin and separated from the palatal plate until its deep raw surface is freely exposed. Langenbeck's incisions are used on each side. Tension stitches are used to hold the edges of this flap. The jaws are now molded, approximated, and the kangaroo tendon suture passed but not tied. The edges of the alveolar margin are then pared. At this stage the raw surfaces of the palatal flaps are approximated and vertical mattress stitches of silkworm gut are inserted. If the flaps are long enough the stitches can be tied at once without danger. If, however, there is any tension, the tying of the stitches must be left until the last stage of the operation. Next the alveolar borders are approximated, the kangaroo tendon tied, and finally the palatal stitches are tied.

Our subsequent experiences with the procedure showed that the first operation is attended with serious shock. In one baby, death undoubtedly resulted from a miscalculation of the seriousness of the procedure. We, therefore, at the present time perform it only in babies who are exceptionally well nourished and robust.

THIRD ALTERNATIVE

Gradually we are coming to the conclusion that the sequence of operations comprised in the "third alternative" offers the greatest degree of safety and enables us to secure the best cosmetic results. The only drawback is a sentimental one, in that we postpone the repair of the lip to the second operation and so prolong the suspense of the parents; otherwise, we divide the stages in an ideal manner and secure the most satisfactory reconstruction. At the first operation we repair the alveolar border, mold the jaws and repair the anterior part of the palate. The jaws are held together with silver wire (preferably) or kangaroo tendon. Brophy's side plates are used only in cases where molding is difficult and the resilience of the jaws cannot be overcome completely. The wires and plates are removed at the end of two weeks and the raw surfaces allowed to heal up completely before the second operation on the lip is performed. Four to six months after the lip has been repaired the posterior part of the palate is repaired "secundum artem."

FOURTH ALTERNATIVE

Practically no cases of Type I in babies should be treated by sequence comprised under the "fourth alternative." A few neglected cases in adults would necessarily fall in this category. As stated before, the sequence becomes necessary in treating cases of Type II, which comprise bilateral clefts of the alveolar margin and complete cleft of the palate.

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Type II.—*Bilateral complete hare-lip; bilateral cleft of the alveolar border; complete cleft of the palate.*

We have previously described the type of plastic operation that gives uniformly good results in cases of complete double hare-lip. Before this operation is undertaken it is necessary to correct the forward projection of the premaxilla and to place it in proper position between the anterior ends of the maxillæ. The outward displacement of the maxillary processes is first corrected. By thumb pressure aided by division of the bone by a chisel or knife, as may be necessary, the maxillæ are pushed towards the middle line until they are approximated to the right degree as verified by measurements with calipers. The premaxilla is then forced backwards until it lies between and a little in front of their anterior horns. Removal of a wedge-shaped portion of the septum allows the bone to slip backwards smoothly. Care must be taken not to jam the premaxilla too far back between the ends of the maxilla. It must always lie a little in front of the projecting edges of the latter bones. If placed too far back, the profile view of the upper lip will be ugly and flattened. When these preliminaries are completed, the mucous membrane is removed from the margins of the cleft on the front of the maxillæ and from the contiguous sides of the premaxilla. Finally the maxillæ and premaxilla are firmly united by strong silver wire sutures fastened over lead plates placed on the sides of the maxillæ, according to the method of Brophy. It is better not to attempt to close the cleft in the lip at this time because it is essential that this stage of the operation should succeed. In three or four weeks the silver wires and lead plates can be removed, and as soon as the gums have healed completely and the mouth is surgically clean, the lip can be repaired. At the second operation the lip is repaired "secundum artem." We invariably use the method described earlier in this paper. The appearance of a double hare-lip immediately after the operation is never as satisfactory as that of a single lip. The nostrils are frequently unsightly, the openings of the nares look forwards instead of downwards, and the tip of the nose is often puckered downwards by the short columella. As time passes these ugly features get smoothed out in a remarkable manner. A period of six months is allowed to pass before any operation on the palate is attempted. Careful measurements are made of the width of the cleft and of the amount of tissue available for flaps, and a judicial estimate made as to the possibilities of a successful plastic operation. If there is the slightest deficiency in the area of available flap, the operation must be postponed without hesitation. However anxious we may be to close the palate before the child learns how to talk, it is far better to wait, rather than run the risk of failure. As time passes we find that the picture changes. The cleft gets narrower, the distance between the alveolar borders decreases and the area of mucoperiosteum on the palatal plates increases considerably. The following observations taken on one of our cases corroborate these statements in every particular. Reference to Figs. 9, 10, 11 and 12 will explain the text.

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The baby first came under observation in November, 1918. She was then five months old. At this time a mold was taken of both upper and lower jaws, life-sized tracings of which are shown in Figs. 9 and 10. (The letters A, B and C, and A', B' and C' refer to points on the alveolar borders that have been described previously. In speaking of the distances AA', BB', etc., we mean a transverse line drawn across the jaw between the points A and A', etc.) The following measurements are recorded:

	Upper jaw	Lower jaw
Distance AA'	42 mm.	33 mm.
Distance CC'	42 mm.	39 mm.

On the lower jaw the points A and A' were difficult to fix accurately and therefore these measurements are only approximately correct. The difference between 42 mm. (for the upper jaw) and 33 mm. (for the lower jaw), which equals 9 mm., represented the amount of separation of the maxillæ. The average widths of the cleft were 13 mm. in front at BB' and 16 mm. at the level AA'. On November 19th the maxillæ were molded and approximated and the premaxilla replaced. Brophy's technic was used. On December 12th the double hare-lip was repaired. On May 1, 1919, the baby was brought for inspection and a mold of the palate was made (Fig. 11). The following measurements were taken:

Distance	AA' = 36 mm.
Distance	CC' = 38 mm.

In addition, further measurements were taken as follows:

1. Distance between the inner borders of the alveolar processes at the level	AA' 30 mm.
2. Width of mucoperiosteum on the right palatal plate at the level	AA' 12 mm.
3. Width of mucoperiosteum on the left palatal plate at the level	AA' 13 mm.
4. Width of cleft at level	AA' 15 mm.
5. Width of cleft at level	CC' 12 mm.

From these measurements the following conclusions were drawn: (a) That the measurement AA' had been reduced by 6 mm. and CC' by 4 mm. (b) That recognizing that the distance (1) 30 mm. must be bridged by flaps (2) and (3), which are, respectively, 12 and 13 mm. wide (= 25 mm.), we are still short 5 mm. of flap to bridge over the defect. (c) That the width of the cleft at AA' was 15 mm. as against 16 mm. at the first measurement, showing a decrease of 1 mm.

Under the circumstances we thought it wise to postpone the operation on the palate until the child was older. On June 1, 1920 (a little over a year later) another mold was made. The following measurements were taken:

The distance AA' was	35 mm.
The distance CC' was	36 mm.
The width of the cleft at AA'	8 mm.
The width of the cleft at CC'	10 mm.
The width of the right palatal plate at the level AA'	13 mm.
The width of the left palatal plate at the level AA'	14 mm.

These figures showed that in a year's time the distance AA' had decreased 1 mm.; distance CC' 2 mm.; in other words, that in spite of the general growth of the child's jaws there had been an actual decrease of the alveolar diameter of the

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upper jaw. They showed further an actual decrease in the width of the cleft of 7 mm. at the level AA' and of 2 mm. at CC'. Added to this we had a slight though appreciable increase in the width of the palatal plates by 1 mm. Allowing for the possibility of error in these measurements the evidence was clear that the jaws were nearer together, that the cleft was narrower and that the palatal plates were broader, and that the prospects of a successful operation had been improved by the delay. The anterior part of the palate was closed by a modified Langenbeck without difficulty.

As a rule these palatal clefts are very difficult to close. I have never seen a case where the whole palate could be repaired at one sitting. As a rule, it is safer to operate on the anterior end of the cleft and close it by a modification of Langenbeck's procedure, leaving the soft palate for a subsequent operation which should be postponed until the anterior part of the palate is completely consolidated and the flaps well vascularized. The method of closure will be easily understood by referring to Figs. 23 and 24.

First stage: A liberating side incision (Langenbeck) is made in the hard palate on one side of the cleft. It is carried well forward and passes backwards almost as far as the posterior border of the hard palate. The mucoperiosteal layer is elevated thoroughly, but the palatal aponeurosis is not divided. On the opposite palatal plate an incision is made which allows a tongue-shaped flap to be thrown up from the underlying bone. The apex of this flap points forward. Its base is attached behind. The tongue flap is now slid across the cleft and sutured to the flap lifted up from the palatal plate of the opposite side. As shown in the figure, a raw area is left in front, which fills up with granulation tissue. The result is usually very satisfactory. Frequently a small hole is left in front which may give trouble (Fig. 23, First palate operation).

Second stage: Reference to Fig. 23 (lower left-hand corner) will show the steps of the operation. Liberating side incisions are made. They are very free and encircle the posterior ends of the alveolar borders and if necessary are prolonged downwards toward the root of the tongue. The hard palate is raised from the underlying bone with a periosteal elevator. It must be freed thoroughly so that it hangs without tension and without being bound down to septum or palatal plates. During this part of the operation great care must be taken not to injure the descending (posterior) palatine artery. Then the soft palate is liberated by the method previously described, if necessary by division of the palato-pharyngeus and levator palati. Finally the edges of the cleft are pared and sutured. Tension on the stitches may be relieved by the use of metal plates. It is our custom to place great confidence in them in these cases.

Type III.—*Lip and alveolar border intact; complete cleft of hard and soft palate.*

We have previously pointed out in this variety that the clefts are usually very wide and that the lateral palatal processes are high and vertical. The anterior end of the cleft is blunt and rounded. As a rule the septum hangs free between the palatal plates. Very few cases are operable in the first year of life because of the extreme width of the cleft and the poverty of available flaps. As time passes the area of the palatal plates increases and the width of the cleft decreases. This favorable change continues slowly but surely until most cases gradually pass into the operable class. The type of operation best suited for these cases is the two-stage operation pre-

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viously described under Type II. At the first stage the hard palate is repaired by sliding a tongue flap across the gap and uniting it to the edge of the opposite flap which has been raised by the Langenbeck method. The operation is confined entirely to the hard palate. A few months afterwards, when the flaps forming the hard palate are thoroughly vascularized and consolidated, the second stage is undertaken and the remainder of the palate repaired "secundum artem." Fig. 24 represents an example of this type, in which complete repair of a very wide cleft was obtained in two operations according to the method described.

The following abstract of cases has been prepared to illustrate the nature and sequence of operations on the palate. They have been arranged to fit in with the scheme embodied in the table of sequences as First, Second, Third or Fourth alternatives. We have purposely omitted reports of cases falling under the third alternative because the true value of this sequence is still "sub judice." We are enthusiastic over the results obtained, but at the present time are not prepared to recommend it unreservedly.

FIRST ALTERNATIVE

CASE I.—M.R., aged six weeks. Right complete harelip; cleft of the alveolar border; complete cleft of hard and soft palate.

First operation July 17, 1918. Repair of lip; molding of maxillæ; repair of alveolar border; suture with kangaroo tendon. Result perfect primary union.

Second operation. (Fig. 17,) aged six months, December 11, 1918. Repair of whole length of palate; Langenbeck's side incisions; silver wire tension stitches fastened over metal plates. Mattress sutures of silver wire and horsehair. Result primary union. A very small opening was left in front just behind the alveolar border. (December 27th the right nostril which was too large was narrowed by a plastic operation.)

CASE II.—F.C., aged three months. Left complete harelip, cleft of the alveolar border; complete cleft of hard and soft palate.

First operation December 10, 1918. Repair of the lip; molding of the maxillæ; repair of the alveolar border; suture of the maxillæ with kangaroo tendon. Result: Primary union.

Second operation June 28, 1919. Aged ten months. Hard palate repaired by taking a flap from the side of the septum. Langenbeck's side incisions used. Mattress sutures of silver wire and silk. Result; primary union. A small hole persisted in front just behind the alveolar border (See Fig. 18. First palate operation).

Third operation November 4, 1919. Repair of the posterior part of the palate. Small hole in the anterior part of the palate almost imperceptible. Langenbeck's side incisions carried far back. Mattress sutures of silver wire and silk-worm gut. Result: primary union (See Fig. 18. Second palate operation).

CASE III.—J.C., aged one month. Right complete harelip; cleft of the alveolar border; complete cleft of hard and soft palate.

First operation March 13, 1919. Repair of the lip; molding of the maxillæ; repair of the alveolar border; suture with kangaroo tendon. Result: primary union.

Second operation. Aged four months. June 6, 1919. Hard palate closed by using a flap taken from the septum. Langenbeck's side incisions employed. Result good. Union complete along greater part of length of hard palate. A

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small hole persisted in front just behind the alveolar border (Fig. 19. First palate operation).

Third operation. Aged eight months. October 23, 1919. Repair of posterior part of hard and whole of soft palate. Langenbeck's side incisions. No attempt made to close hole in front just behind alveolar border. Result: complete healing (Fig. 19. Second palate operation).

Fourth operation. Aged one year. February 25, 1920. Repair of hole in anterior part of the hard palate. Langenbeck's side incisions and complete separation of flap A which was made to slide over to the right. Result: complete healing (Fig. 19. Third palate operation).

SECOND ALTERNATIVE

CASE I.—E.B., aged seven months: Left complete harelip; cleft of the alveolar border; complete cleft of hard and soft palate.

First operation July 18, 1919. Repair of lip; molding of maxillæ after chiseling through malar buttresses; repair of alveolar border; suture of maxillæ with kangaroo tendon. Repair of extreme anterior end of hard palate after liberation of flaps by small side incisions. Result: primary healing (Fig. 20. First operation).

Second operation. Aged ten months. November 11, 1919. Repair of whole length of hard palate by using septal flap and making Langenbeck's side incisions. Result: failure of union caused by sloughing of edge of the flap on the left side (Fig. 20. Second operation).

Third operation postponed until baby was two years old. November 22, 1920. Repair of hard and soft palate at one sitting. Langenbeck's side incisions used. Result excellent. Primary union. (Fig. 20. Third operation.)

NOTE.—In this case the attempt to close the anterior part of the palate at the first sitting was successful as far as it went. We succeeded, however, in closing only a very short length and did not use a septal flap. In the second operation the cleft was so wide that a septal flap was needed. The operation was very difficult. The result was that most of the line of union failed to heal. We never repeated the technique of the first operation. In subsequent operations we always used a septal flap. The case may be considered as a transition from the first to the second alternative.

CASE II.—J. H., aged one month. Right complete harelip; cleft of the alveolar border; complete cleft of hard and soft palate.

First operation March 31, 1920. Repair of lip; molding of maxillæ; repair of anterior part of palate by a septal flap. Result excellent; primary union (Fig. 21. First operation).

Second operation July 28, 1920, aged five months. Repair of posterior part of the palate; Langenbeck's side incisions. Double silver wire tension stitches fastened over buttons. Suture of silver wire and horsehair. Result: primary union. Complete repair (Fig. 21. Second operation).

CASE III.—F. N., aged six weeks. Right complete harelip; cleft of the alveolar border; complete cleft of hard and soft palate.

First operation March 17, 1920. Repair of lip; molding of maxillæ; repair of alveolar border; suture of maxillæ by kangaroo tendon; closure of front part of cleft in hard palate by means of a septal flap. Result: primary healing (Fig. 22. First operation).

Second operation. Aged six months; July 10, 1920. Repair of posterior part of palate; cleft very wide; area of velum very narrow. Langenbeck's side incision carried far back, especially on right side where it encircled posterior border

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of alveolus. Result: failure of union at junction of hard and soft palate. Side of velum united (Fig. 22. Second operation).

Third operation. Aged ten months. November 4, 1920. Condition as follows: Two holes present, one anterior showed as a median slit occupying posterior quarter of hard palate; the other laterally placed at junction of hard and soft palate (Fig. 22. Third operation). Palate closed after being liberated thoroughly by incision shown by dotted lines. The rectangular piece outlined by the dotted line was excised and the raw edges united by four silver wire sutures.

FOURTH ALTERNATIVE

CASE I.—M. F., aged five months. Complete bilateral harelip and complete cleft of the palate; vomer free; very prominent premaxilla (For sketch of cast of palate, see Fig. 9).

First operation November 19, 1918. Molding of maxillæ and replacement of premaxilla after excision of a triangular piece from the septum. Silver wires and plates used according to Brophy's technique. Result good.

Second operation December 12, 1918. Repair of double harelip according to method described previously. Result: primary union lip excellent. On May 1st, 1919, a mold of the palate was taken, a sketch of which is shown in Fig. 11.

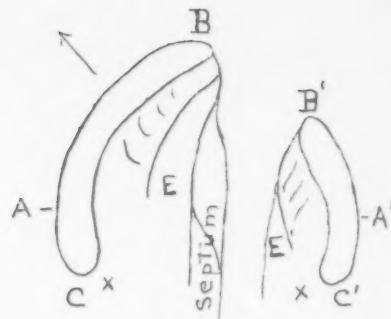
Third operation. June 1, 1920. The anterior part of the palate was closed by a modification of Langenbeck's operation. A tongue shaped flap was lifted up from the left side and dissected up as far back as the junction of hard and soft palate. On the right side the flap was lifted up as in Langenbeck's procedure, the free edge being lifted up very carefully along the whole length of hard palate. After sliding the tongue flap across the cleft the edges were fastened together with mattress stitches. Result: primary union (See Fig. 23. First palate operation.)

Fourth operation April 14, 1921. (Refer to Fig. 12, a sketch of a plaster mold). Repair of posterior part of palate. Langenbeck's liberating side incisions carried backwards and curved around the posterior end of the alveolar ridge; incision through mucous membrane carried from bend of curve towards tonsil. Liberation of hard palate from bone, division of palato-pharyngeus and levator palati muscles. Silver wire tension stitches fastened over metal plates, mattress sutures of silkworm gut. Result: primary union (See Fig. 23. Second palate operation; and Fig. 12, a sketch of a plaster mold of reconstructed palate.)

CASE II.—R.H.McM. aged eleven days. Double harelip; alveolar border grooved but not cleft; complete cleft of palate behind alveolar border. Septum free. Cleft unusually wide along its whole length. Lip repaired at once. June 26, 1919. Result good.

Second operation on anterior part of palate March 23, 1920. On right side of palate mucoperiosteal flap elevated through a long Langenbeck side incision. On left side mucoperiosteal flap lifted up from bone like a tongue and separated from the posterior margin of bony palate. The tongue flap was carried sideways across the cleft and its free edge united by mattress sutures with that of the opposite side. No attempt was made to close the posterior end of the cleft. Result: primary union along the whole length of repair. (Fig. 24. First palate operation.)

Third operation March, 1921. At this time a very small hole was present just behind the alveolar border. Behind this the hard palate was firmly united to a point on a line of junction of hard and soft palate. Liberating side incisions carried well backwards around the posterior ends of the alveolar margins. Division of palato-pharyngeus and levator palati muscles. Cleft was very wide and palate had to be loosened very extensively. Suture with silkworm gut mattress stitches. Result: primary union. (Fig. 24. Second palate operation.)



Shaw

FIG. 1.—Life sized sketch of a plaster mold of the palatal surface of the maxillary plates of a case of unilateral cleft of the alveolar border and complete cleft of the palate. The letter E is placed on the right maxillary plate to which septum and premaxilla are attached. The letters A, B and C refer to points on the alveolar border which are described in the text. The cross is placed over the hamular process. The arrow shows the direction in which the larger plate is forced outwards by the tongue thrust.



FIG. 2 A.—shows photographs of the head of a seven months foetus in which a complete cleft of the lip, alveolar border and palate was present. On the right the external appearance of the flaring nostril, and the cleft in the lip are well depicted. The tongue and alveolar margin of the mandible stand out in relief. On the left we see a coronal section of the face passing through the middle of the palate. The anatomical features of both photographs are emphasized and labelled accurately in Fig. 2 B.

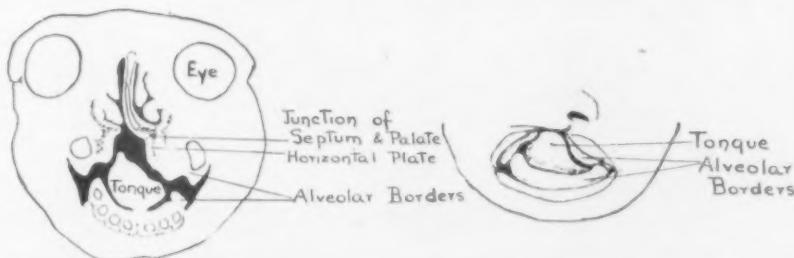


FIG. 2 B.—Drawing of previous figures to show the exact relations of the palatal plates to one another and the exact boundaries of the cleft. The site of fusion of left palatal plate and septum is indicated by an acute bend. The lower part of the septum is bent like a hockey stick. Both palatal plates have been pushed into a vertical position. The free edge of the right palatal plate (left in the figure) is considerably higher than that of the left. The alveolar border of each maxillary process lies outside that of the mandible. Under normal conditions the alveolar border of the mandible should lie a little outside that of the maxilla. The tongue occupied the space between the separated maxillæ. The apex of the triangular-shaped section was placed between the edge of the left maxillary plate and septum.



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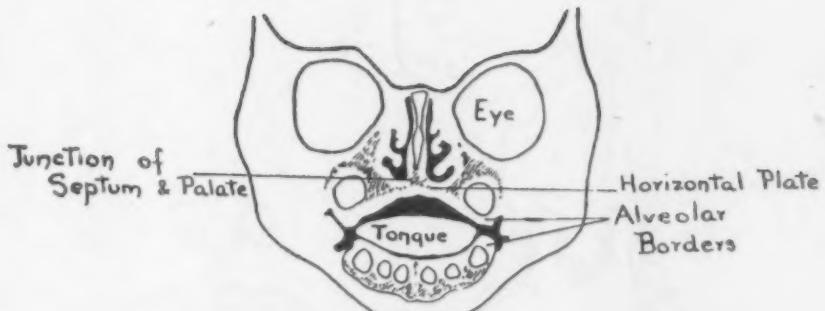


FIG. 3.—A drawing of a coronal section of the face of a normal fetus at term. The palatal plates and septum have united. Note the shape of the tongue molded to the normal palatal arch. The alveolar border of maxilla and mandible articulate with each other accurately on the left side. On the right that of the maxilla is slightly outside the alveolar border of the mandible.

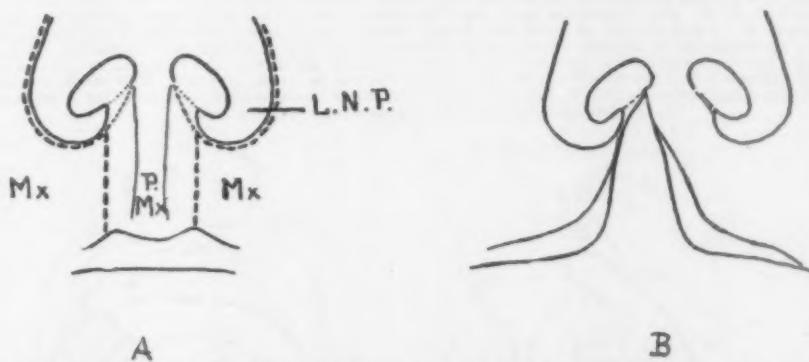


FIG. 4.—The figures show in the lip and nostril the lines of fusion of maxilla and premaxilla which is emphasized by the dotted line. The ring of the nostril is completed below by the fusion of external and internal nasal processes. This is indicated in A by a triangular area bounded by black dots. In B an example of incomplete hare-lip is shown, in which the margin of the nostril is intact, the lower part being formed by the external nasal process.

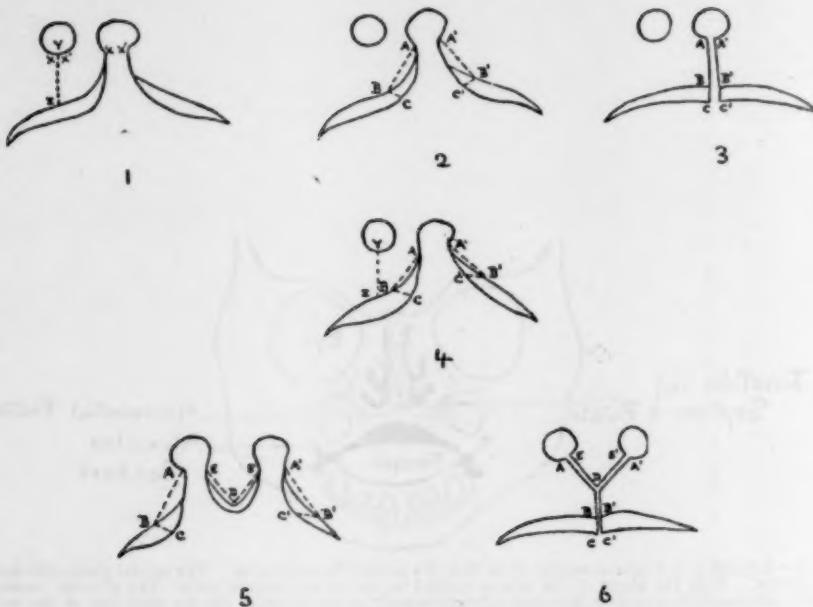


FIG. 5.—The numbers 1, 2, 3 and 4 illustrate the method employed in operating on single hare-lip. The measurement Y Z in No. 1 determines the depth of the lip. In planning the incision the point A is placed on the margin of the nostril, B is at the mucocutaneous junction and C is on the free margin of the lip. A', B' and C' are similar points on the opposite side of the cleft. The distance A B is made equal to Y Z. The distance B C is a little greater than the shortest depth of the mucocutaneous margin. The distance A B = A' B' and B C = B' C'. No. 3 shows the result when the edges of the incision are brought together preparatory to suture. No. 4 is an example of a cleft with widely divergent sides and irregular depth of mucocutaneous margin. It brings out the irregular direction of the incisions required to secure accurate coaptation. In the numbers 5 and 6, the steps of the operation used in double hare-lip are shown. The diagrams are self-explanatory. The distance A B, which determines the depth of the lip, is more or less arbitrary. It is usually obtained by drawing a line across the cleft with a probe bent to represent the repaired lip and dropping a perpendicular to this line from the coapted margins of the nostril A and A'.

FIG. 6.

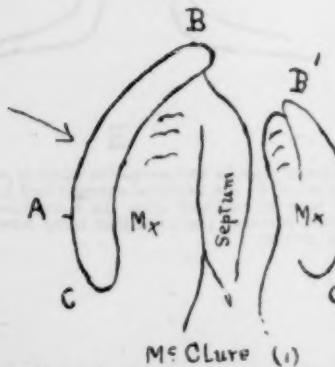


FIG. 7.

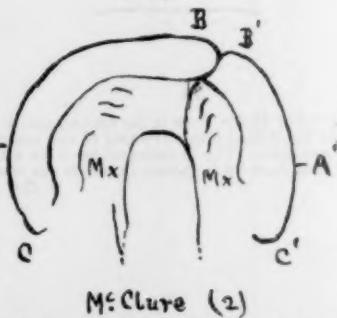
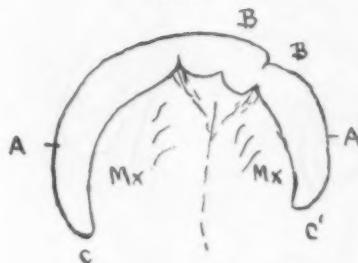


FIG. 6.—Life sized tracing of a plaster mold of a case of complete unilateral hare-lip, cleft of the alveolar border and complete cleft of the palate. The lettering is identical with that used in Fig. 1. The arrow represents the direction of pressure in molding the maxilla.

FIG. 7.—Same case as Fig. 6. Tracing of a mold taken some months after repair of the lip, alveolar border and anterior part of the palate.

OPERATIONS FOR HARE-LIP AND CLEFT PALATE

FIG. 8.

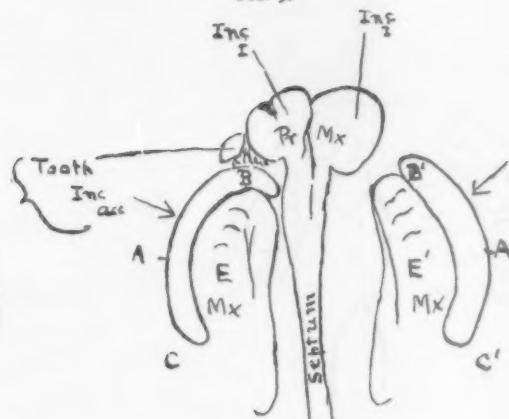


Mc Clure (3)

FIG. 8.—Same case as Fig. 6. Tracing of a mold of complete palate. The alveolar borders stand out in relief and the line of palatal union is well shown. The uvula made no impression on the wax mold.

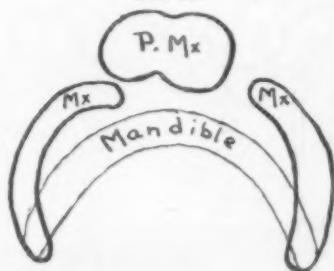
FIG. 9.—Life sized tracing of a plaster mold of a case of double complete hare-lip, double cleft of the alveolar border and complete cleft of the palate. All the features are described in the text. The arrows show the direction of pressure in molding the maxillæ in the first operation.

FIG. 9.



Farmer (1)

FIG. 10.

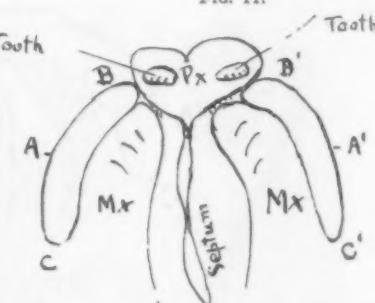


Farmer

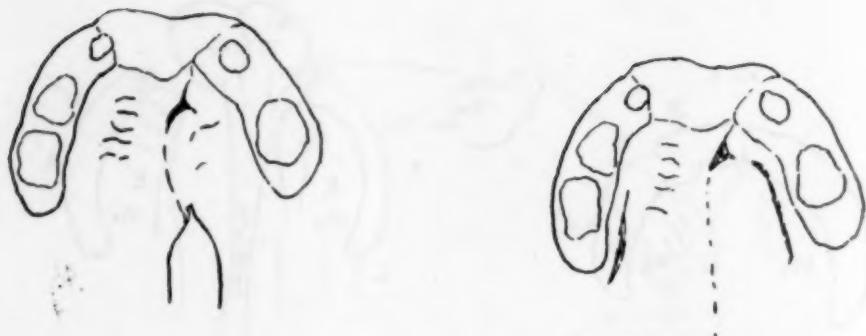
FIG. 10.—Outline sketch of superimposed alveolar borders of maxilla, premaxilla and mandible of Fig. 9., to show their articulation.

FIG. 11.—Same case as Fig 9., showing a sketch of a mold of the palate taken after the jaws had had molded. This case was taken six months after the operation on the alveolar border.

FIG. 11.



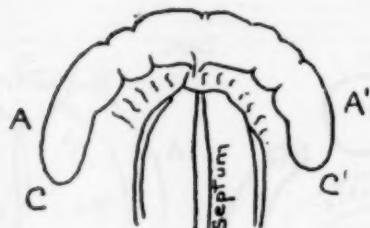
Farmer (2)



Farmer (3)

Farmer (4)

FIG. 12.—Same case as Fig. 9, showing sketches of molds of the palate in the various stages of repair. On the left the result of the operation for repair of the anterior part of the palate. On the right the result of a subsequent operation for the repairs of the posterior part of the palate is shown. The steps of these operations are depicted in detail in Fig. 23.



Dishman

FIG. 13.—Life sized tracing of a plaster mold of a case of complete cleft of the palate associated with intact alveolar margin and lip. Note the very wide cleft with vertical lateral palatal plates. The anterior end of the cleft is very wide and rounded. The septum hangs free.

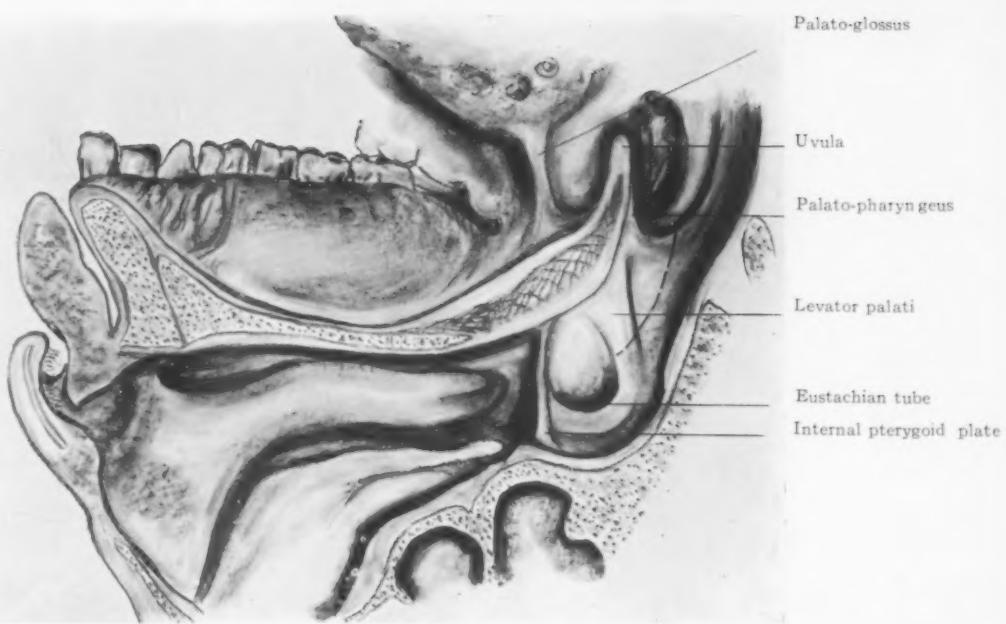


FIG. 15.—Original diagram of the soft palate showing the position of the palato-pharyngeus and levator palati muscles. The dotted line indicates the position of the incision through the mucous membrane to relieve tension.

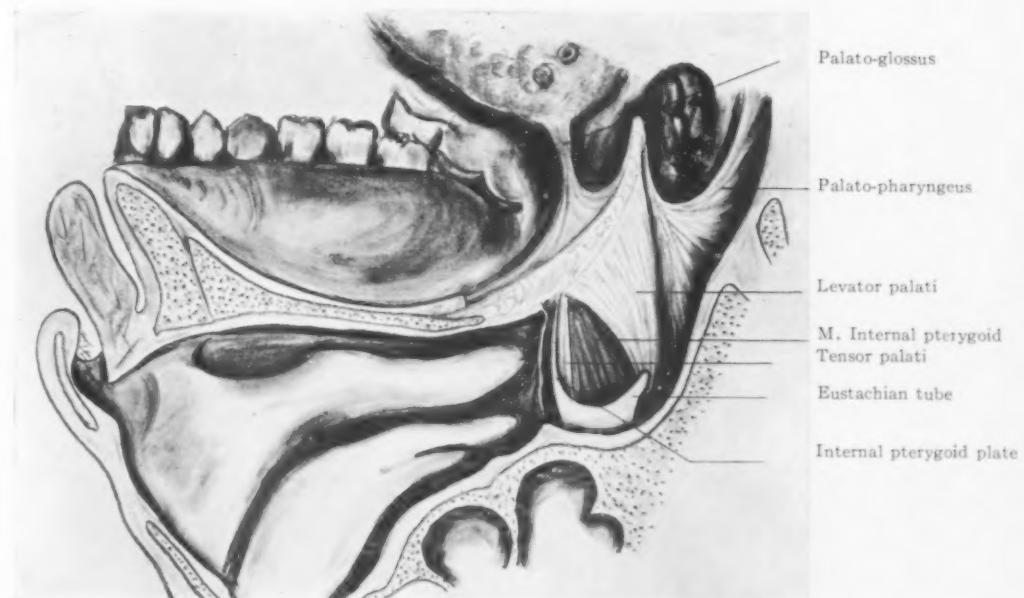


FIG. 16.—Dissection of the specimen from which Fig. 15 was drawn, showing the muscles. The labelling of the figure is explanatory.



OPERATIONS FOR HARE-LIP AND CLEFT PALATE

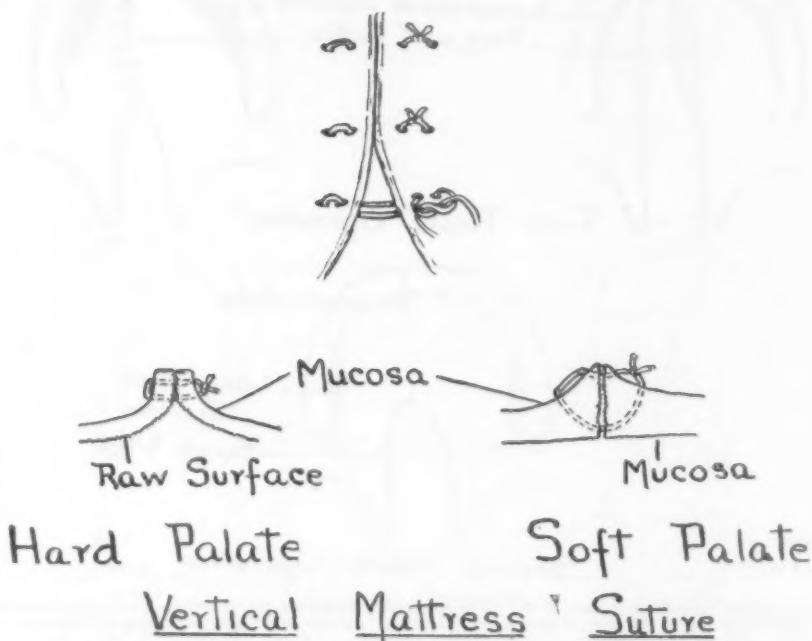


FIG. 14.—Shows the method of passing the vertical mattress sutures. In the upper figure the two upper stitches are tied very loosely, the lower one is not tied. It is clear that stitches passed, in this manner cannot strangulate the blood supply to the edges of the flaps. In the lower figures, we see cross sections of the stitches tied tight. On the left the raw surfaces of the hard palate are seen to be held firmly together over a large area, and the edges turned out like the flanges of a water main. On the right the stitch is shown passing through mucosa on buccal surface of palate but not penetrating mucosa on cranial surface. This technique is of the greatest value.

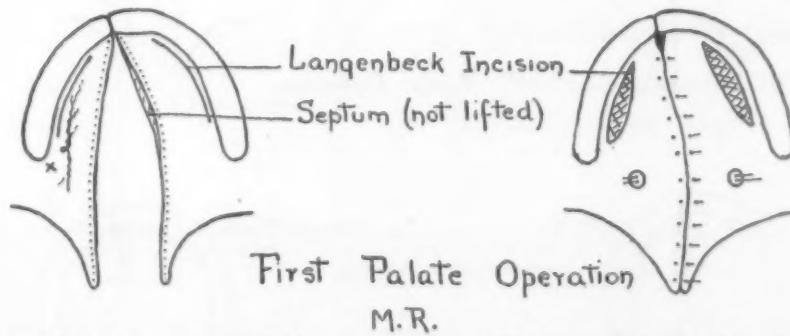


FIG. 17.—Sketch of the palate operation in case of M. R. reported in text, repaired from end to end in one operation. This case was reconstructed in two operations. In the first the lip and alveolar border were repaired. In the second the whole palate. Repair was completed at the age of six months. On the left the position of the posterior palatine artery is shown in red coloring. The relation of Langenbeck's liberating side incision to the artery is clearly brought out. It is evident that the incision could be carried backwards around the posterior end of the alveolar process without injuring the artery, if due care were taken to keep close to the alveolus. The cross is on the hamular process. On the right the palate is shown with all the sutures in place. Small metal buttons with wire tension sutches are shown in the velum. In this diagram and most of the subsequent ones the velum is drawn unnecessarily long.

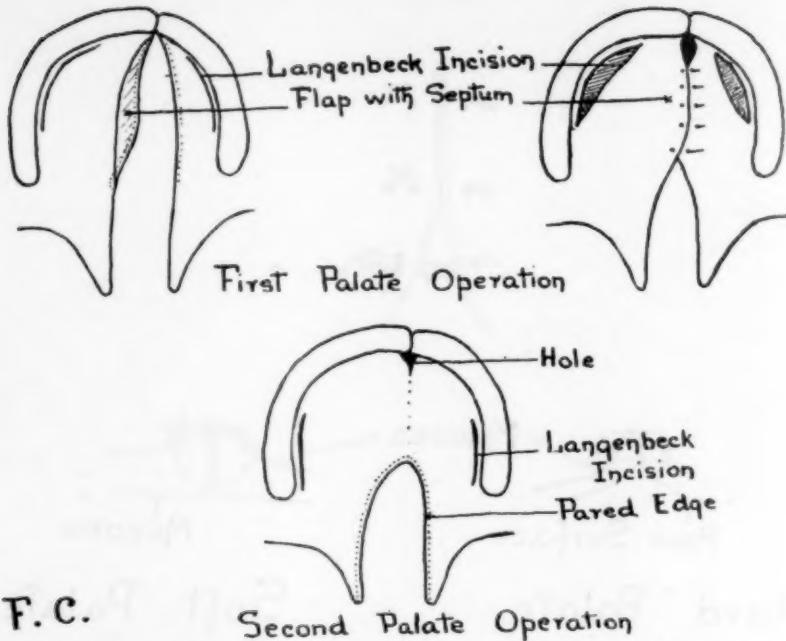


FIG. 18.—Palate operations in case F. C. The first palate operation left a hole in front, which is shown much reduced in size at the time of the second operation. An almost imperceptible hole still persists.

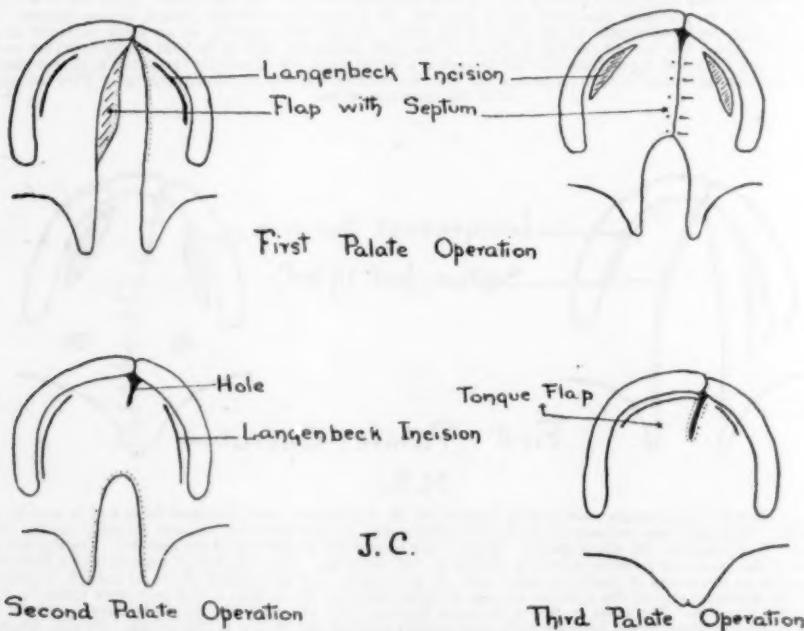


FIG. 19.—Palate operations in case J. C. The first operation left a hole in front. No attempt was made to repair this at the second operation when the posterior part of the palate was repaired successfully. At the third operation the hole was closed by sliding a tongue flap across the gap from the right side of the palate.

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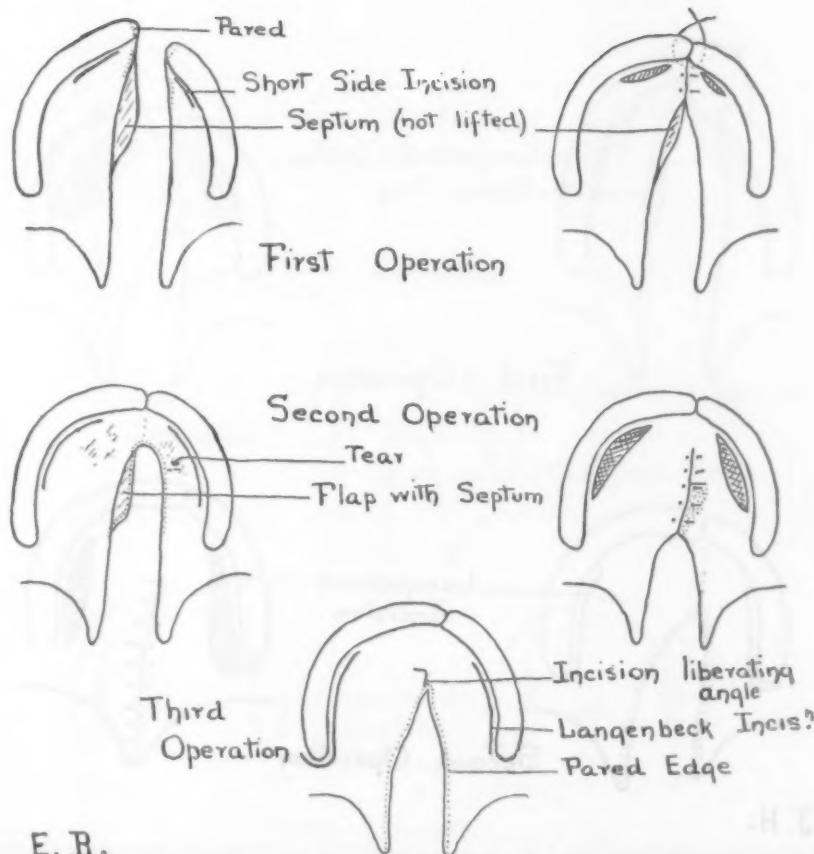


FIG. 20.—Palate operations in case E. B. They show repair of the palate in three stages. At the original operation on the lip and alveolar border an attempt was made to close the anterior part of the hard palate by uniting the edges of the mucoperiosteal flap covering the palatal plates. Short Langenbeck's incisions were used. The septal flap was not used. The result was good. At the second operation the remainder of the hard palate only was repaired. A septal flap was used and very short Langenbeck incisions. The left flap sloughed and the result was a failure. At the third operation we employed very extensive Langenbeck's incisions; that on the right was carried in a curve around the end of the alveolar border. At the front end of the cleft we made an L-shaped cut to blierate the angle. The result was a success.

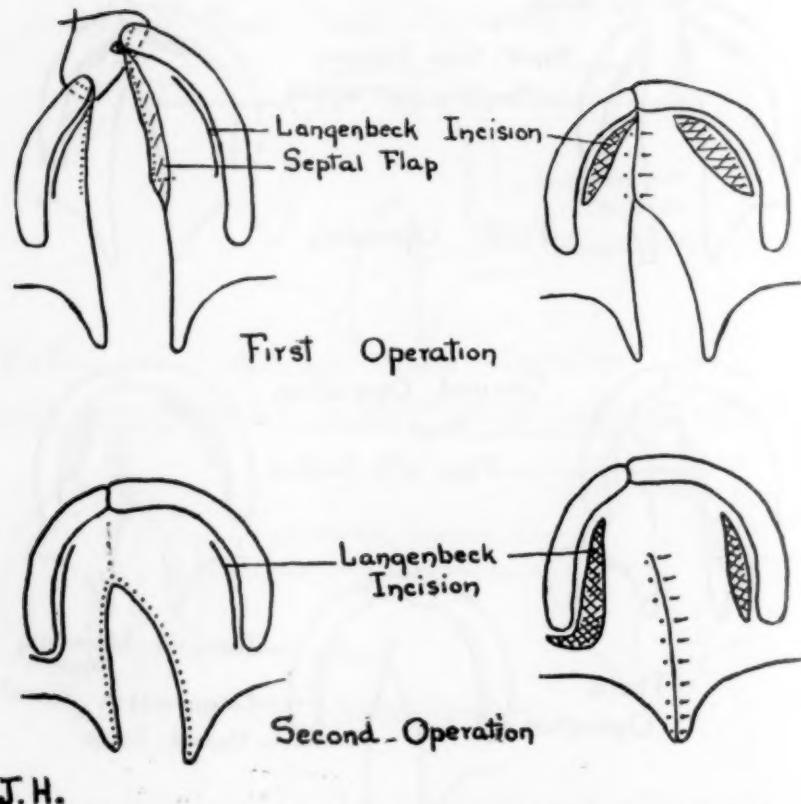


FIG. 21.—Palate operations in case J. H. In the case the anterior part of the palate was repaired successfully at the same sitting with the alveolar border and lip (second alternative). The posterior part of the palate was repaired successfully a few months later by using Langenbeck's incisions, as shown in figure. Reconstruction was complete at the end of five months.

OPERATIONS FOR HARE-LIP AND CLEFT PALATE

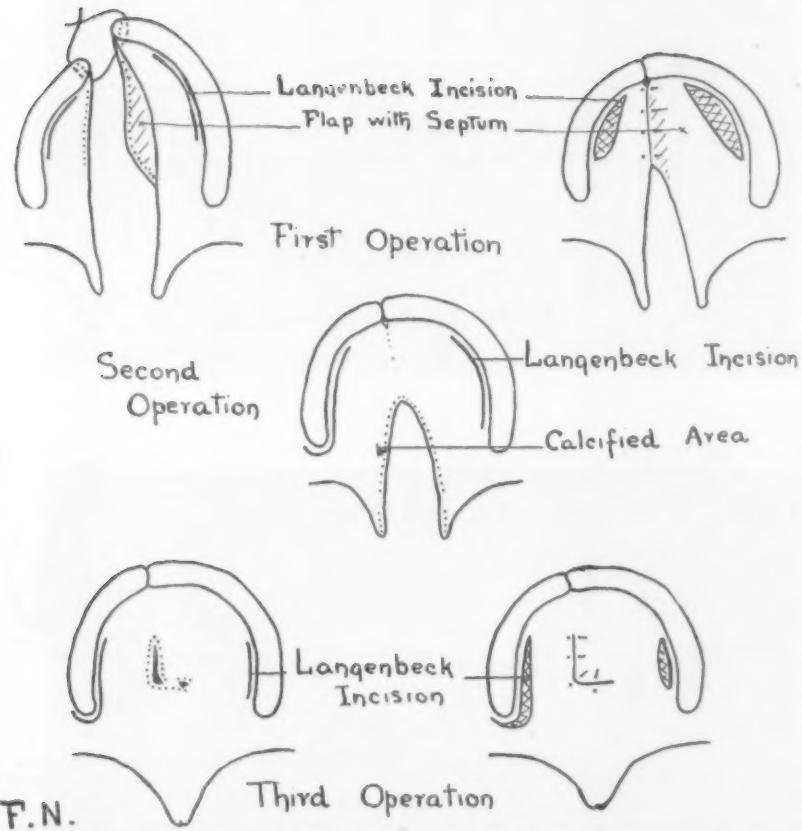
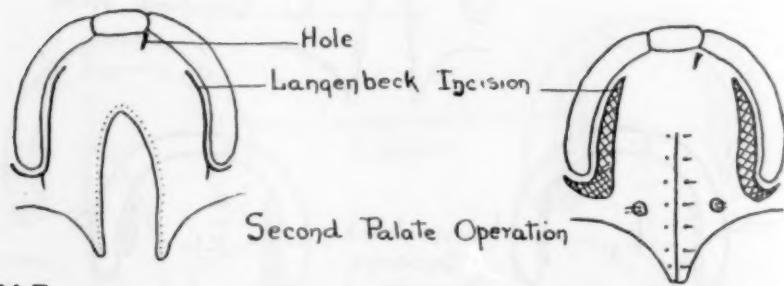
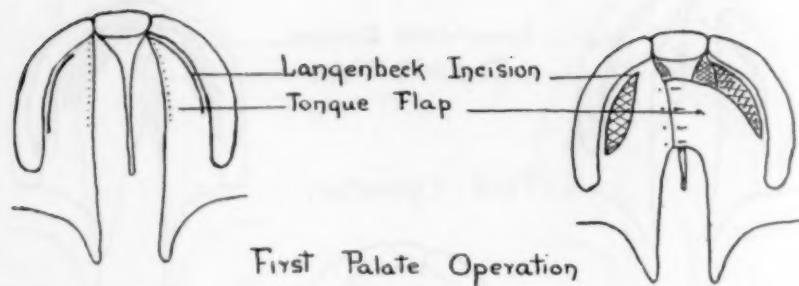


FIG. 22.—Palate operations in case F. N. At the first operation the lip, alveolar border and anterior part of the palate were repaired successfully. At the second operation the posterior part of the palate was closed successfully, with the exception of a part in the middle where two small holes were left. These were closed subsequently by a plastic procedure shown in the third operation. This necessitated extensive liberation of the palate by Langenbeck's side incisions.



M.F.

FIG. 23.—Palate operations in case M.F. This was a case of double hare-lip and complete cleft palate. The anterior part of the palate was closed by a tongue-shaped flap which was lifted up from the left palatal plate brought across the cleft and united with the edges of a flap lifted up by Langenbeck's method from the right palatal plate. The result was a complete success. A very small hole persisted in front. At the second palate operation extensive Langenbeck's incisions were used. Both were curved around the posterior ends of the alveoli and carried backwards towards the base of the tongue. Brophy's tension stitches and metal buttons are shown in the soft palate. The result was a success.

FIG. 25.



FIG. 26.



FIGS. 25 and 26.—(D. G.) Case of double hare-lip and complete cleft palate showing result of lip operation described in text. The photograph of the repaired lip shows well formed nostrils and a very satisfactory philtrum well supported by the premaxilla. The lower part of the lip is rather tight and drawn. This will be remedied when teeth appear in the premaxilla.

FIG. 27.



FIG. 28.



FIGS. 27 and 28.—(E. B.) Case of single hare-lip and complete cleft palate. The photograph taken before operation shows the left flaring flattened nostril and marked deviation of the nose to the right. In the photograph taken ten days after the operation, at which time the jaws were molded and alveolar border repaired, the nostril is of natural size and the nose is straight. The red line of the lip has been restored and the lip is deep enough. The depression on the left of the line of union on the lip margin is not a notch but is produced by a slight twisting of the lip near the angle of the mouth.

OPERATIONS FOR HARE-LIP AND CLEFT PALATE

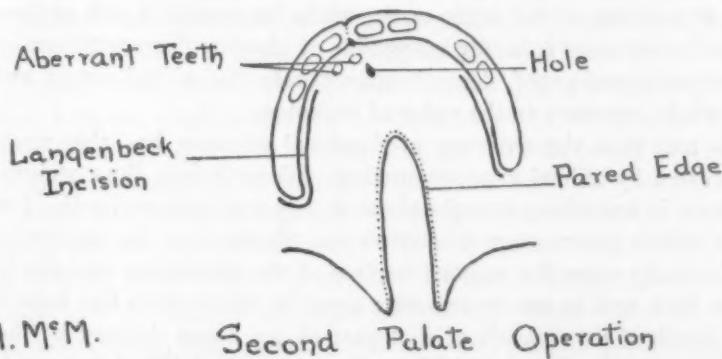
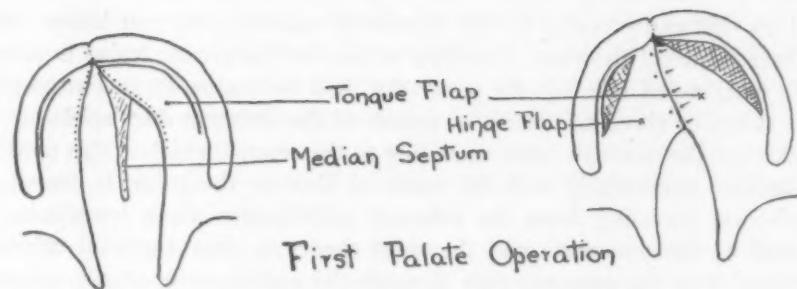


FIG. 24.—Palate operations in the "case" of H. McM. This was a case of double hare-lip with intact alveolar border. The palate and septum are shown in the upper figures of the first palate operation. The left maxillary palatal plate and septum had fused. The tongue flap was taken from the left side. The result was a success. At the second operation extensive Langenbeck's incisions were employed, that on the right curving around the posterior end of the alveolar border. Result successful.

FURTHER DATA CONCERNING THE EXPERIMENTAL PRODUCTION OF PANCREATITIS*

BY EDWARD ARCHIBALD, M.D.

OF MONTREAL, CANADA

ARMED BY

E. C. GIBBONS, MED., '23

THE problem of the exact cause of pancreatitis and of the exact mode in which that cause works is still somewhat unclear. As you know, there are three principal theories: according to one the pancreatic lesion is caused by the entrance of bile into the pancreatic duct by reason of an obstruction, either stone, or shred of mucus, or spasm of the common duct sphincter, at the outlet of the common duct; according to the second, which in this country is associated particularly with the name of Deaver, the lesion is caused by an infection traveling from the inflamed gall-bladder along lymphatics to the head of the pancreas; and the third theory is that duodenal contents are forced into the common duct through the papilla, temporarily relaxed, and so into the pancreatic duct. Of these theories the first and the third may be considered as proved for a considerable proportion of the cases reported, at any rate of the acute cases; while the second is still under discussion, and in any event is hardly susceptible of absolute demonstration—it lacks as yet experimental proof, depends upon purely clinical inferences, and goes, on the whole, contrary to the rules of pathology.

It is true that the entrance of duodenal contents has also never been demonstrated by animal experimentation. Nevertheless, the conclusion that pancreatitis is sometimes brought about in this way imposes itself. I refer to cases in which postmortem dissection has shown that the pancreatic duct opened directly upon the mucous surface of the duodenum and not into the common duct, and to one or two rare cases in which there has been demonstrated localized pancreatitis of that part of the organ drained by the small duct of Santorini. These conditions, however, are fulfilled but rarely; and most of our evidence, both clinical and experimental, goes to show that the entrance of bile into the pancreatic duct is by all odds the most frequent mode of causation. This hypothesis has now got outside the bounds of mere theory and is widely accepted as being definitely proved.

I need not in this place recount the history of the clinical and experimental work which has been published in support of this proposition, but shall confine myself to recalling to your minds certain outstanding facts of the experimental work which has engaged my attention for the past few years, and which I presented before this Society two years ago. It was proved that in cats, in which animals the anatomical relationships of the common and the pancreatic ducts resemble those present in the human much more exactly

* Read before the American Surgical Association, June 15, 1921.

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than they do in other laboratory animals, it was possible to run a solution from the gall-bladder under a pressure of from 300 to 600 mm. of water into the pancreas to such an extent that even the finer radicles between the acini were found filled with the solution. In later experiments it was found possible in the same way to run bile, infected or not, solutions of bile salts, and mucin-free bile, from the gall-bladder into the pancreas with consequent production of various grades of pancreatitis from the least severe up to the acute hemorrhagic form, with death inside an hour. In all these cases the only obstruction possible lay in a resistance of the common duct sphincter.

From a consideration of these experimental facts and of clinical experience it seemed justifiable to present the problem of the etiology of pancreatitis in the following way. "The conditions for actual serious damage to be done in the pancreas must pretty certainly be three: (1) a change in bile composition, increasing the proportion of bile salts; (2) undue resistance, perhaps often amounting to spasm, of the common duct sphincter; and (3) abnormal rise of pressure in the biliary system behind, either in the gall-bladder or in the common duct.¹

"Our problem, therefore, is to discover in the facts of clinical experience circumstances fulfilling these postulates. Here we come on to uncertain ground. It is probable that hyperacidity may have a good deal to do with it. Symptoms indicating hyperacidity are frequently found in the previous history of patients with pancreatitis (Egdahl, 14). Certainly the injection of hydrochloric acid into the duodenum or even into the stomach (Oddi) will cause a spasm of the sphincter. In man we are still unacquainted, so far as I know, with the condition of the duodenal contents as regards the length of time which is necessary for neutralizing the acid chyme of the stomach. In alcoholics, anyhow, and in patients who have duodenal ulcers, it would seem probable that the duodenal contents might remain acid for some time, and in these two classes pancreatitis is rather frequent. One recalls in this connection three cases published by Dr. William J. Mayo, in which acute pancreatitis was present, without gall-stones anywhere, but with, in each instance, a duodenal ulcer situated close to the papilla, presumably causing hyperacidity.

"In the second place, that change in bile which results in a high concentration of bile salts and a diminution of bile mucin is probably brought about by the effect of gall-stones, especially when associated with inflammation. In infected bile, it is pretty certainly not the bacteria acting in their infecting capacity that cause the pancreatic lesion, but rather the chemical change in the bile produced by the action of bacterial growth. This at least was strongly suggested by the work of Flexner, of Carnot, Hlava, and others; and the present experiments, in which sterile bile and a solution of sodium taurocholate caused the lesion equally with infected bile, tend to confirm this view. I am unacquainted with any work upon the chemical composition of infected bile, but it may be presumed that the action of bacteria is to pre-

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cipitate the mucin of bile; and indeed we see the evidence of it in the shreds observed in the bile in cases of cholecystitis and cholangitis. If this is the case, it is probable contrary to the assumption of Flexner, that the relative proportion of the bile salts is increased. I may add that Doctor Harding, Associate Professor of Chemistry in McGill University, is beginning work along this line. It must be pointed out, however, that the effect of bacteria upon the bile seems to increase very greatly the destructive effect of that bile upon the pancreas; and while this is still probably due to some chemical change in the bile it seems likely that there come into play, in addition to the bile salts, new substances possessing necrosing properties.

"It may be noted also that any obstruction in the cystic duct would probably deprive the bile of a part of its mucin content normally provided by the gall-bladder mucosa; and in such cases, theoretically at least, the occurrence of a pancreatitis may be rendered more likely.

"In the third place, the condition of increased pressure in the biliary system is presumably brought about partly by an increased resistance of the sphincter, set in motion by hyperacidity or by neighboring ulcers; partly by a sudden blocking of the cystic duct by stone or inflammation; and finally, perhaps, by any unusual increase in the amount of bile secreted by the liver. The effect of a full meal, two or three hours after which, as we see in so many case reports, the attack of pancreatitis is apt to come on, may be in the direction of increased bile production rather than in that of increased pancreatic secretion."

The present work represents a small effort to get deeper into these problems. Fourteen cats have been used. A later report will give details of the experiments performed. Briefly, we have injected ox bile, infected with various organisms, as well as human bile aspirated at operation from acutely inflamed gall-bladders, into the gall-bladder of cats, under pressure, either by running it in from a raised funnel or by squeezing of the gall-bladder. In most, the bile entered the pancreas. We have also injected by syringe direct into the pancreatic substance cat's own bile, human bile from distended inflamed gall-bladders, in one case complicated by very acute pancreatitis, the same human bile several days later running clear and normal-looking from the cholecystostomy tube. We have reopened at intervals, cut out sections of pancreas for microscopical examination, and have taken cultures from the interior of the pancreas often recovering the original organism, thus proving penetration of bile. We have injected HCl into the duodenum to stimulate the sphincter.

Microscopically we have found all grades of pancreatic necrosis of the parenchyma, with much or little stroma reaction, edema, congestion, hemorrhage, going on after one to four weeks to advanced replacement fibrosis, local or diffuse. We could follow the development of interstitial pancreatitis, a pancreatic cirrhosis from the original necrosis, through fibroplastic repair.

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The investigation has been directed chiefly along the following lines: In the first place, what effect does infection in bile produce upon the relative proportions of the bile salts and the mucin? Secondly, what difference, if any, exists between the action of infected bile on the pancreatic parenchyma and that of normal bile? Third, is it necessary that an abnormal degree of the force which expels the bile should be present before the pancreatic duct is invaded, and if so, what is the nature of that abnormal force? Finally, under what condition is the common duct sphincter brought into resistance to the flow of bile into the duodenum?

I. *The Chemical Examination of Infected Bile.*—During the past winter Mr. Logan, working in the Chemistry Department of McGill University, under Doctor Harding and Professor MacCallum, has been analyzing, according to the methods of Foster and Hooper, samples of bile which I have brought him from the wards of the Royal Victoria Hospital, together with specimens of bile from the ox, the hog, and the cat. These biles have been variously infected. My idea was that as the result of infection the mucin of bile might be precipitated in such an amount as to leave the bile salts in a much higher proportion, and greater concentration, than in normal bile, and that such a bile being forced into the pancreas would presumably cause a more definite and more severe pancreatitis. Flexner showed that it was the bile salts that caused pancreatic necrosis, while the mucin had a protective action. Our work leaves this supposition as yet unconfirmed. Clinical experience, on the whole, seems to indicate that the more serious cases of pancreatitis are associated with conditions of serious inflammation in the gall passages. Mr. Logan's work is still very incomplete. The difficulties of the subject are much greater than the uninitiated might suppose, and I am unable to make any very definite report upon this part of the work. On the one hand, the actual amount of bile salts excreted in the bile varies very greatly according to the nature of the diet, chiefly, but varies anyhow on a mixed diet from day to day (Hooper and Foster). On the other hand, the amount of mucin in a normal fistula bile remains fairly constant. The amount of mucin, when the bile has been infected, shows in some cases a slight increase, in others a slight decrease. The analyses, so far, which have been carried out with several of the ordinary organisms, staphylo- and streptococci and *B. coli*, are insufficient in number to give any sure indication on this point. We expect to carry on the work during the coming year. But for the present it looks as if our hypothesis as to the greater concentration of bile salts as the result of infection remains unsubstantiated. There is probably something else in infected bile which is responsible for the more severe necrosing effect which it shows as compared with normal bile. Upon this point several of the experiments are most positive. One of these in detail is as follows:

Cat 190. Bile aspirated from gall-bladder at operation on a case of acute cholecystitis with impacted stone in cystic duct. The bile was blackish green and was obviously infected. Culture showed a scant growth of streptococcus. The gall-bladder was drained. A portion of

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the original infected bile was injected with syringe into the splenic end of a cat's pancreas, and another portion of the drainage bile, which three days after operation had become clear and normal looking, was injected into the duodenal end of the same pancreas. After two days the cat was reopened, and it was found that the infected bile had caused a very marked inflammatory reaction, with fat necroses in the adjoining omentum. In marked contrast with this, the more normal drainage bile had left the duodenal end almost normal. These two areas were cut out and sectioned, and the difference in necrosing effect was confirmed. At the splenic end the necrosis of parenchyma was extensive and there was a great deal of oedema and congestion, while at the duodenal end there was very slight necrosis, little oedema, and practically no congestion.

This observation was confirmed with two other cases of acutely infected bile from cases of acute cholecystitis, and in still another one the same contrast was found between the effects of cholecystitic bile and the cat's own normal bile.

The difference is one of degree. Even normal bile entering the pancreas causes necrosis of the pancreatic parenchyma with which it may happen to come in contact. But this necrosis is aseptic, is accompanied by little, if any, surrounding reaction, whereas the infected bile causes a more massive and extensive necrosis with a great deal of oedema, congestion, even hemorrhage, and with much inflammatory response on the part of the fixed connective tissue. Fat necroses also are often more abundant.

While these results were obtained by the direct injection of bile through a needle, we were able to determine that similar results, and like differences, were found when the bile entered through the pancreatic duct from the gall-bladder. It may here be said that in the present series, as in that of two years ago, in a majority of the experiments in which any pressure was applied from behind, that is on the gall-bladder, the bile entered the pancreatic duct to some extent, as was evidenced by the finding of necrosis. In some instances the effect seemed localized to the central part of the gland nearest the entrance of the pancreatic into the common duct, while in others the bile had invaded the whole gland.

The degree of swelling of the organ was variable. One fact in particular is noteworthy, which was that there might be macroscopically very little evidence of any lesion in the pancreas in the way of swelling or congestion, and yet microscopically necrosis might be quite extensive. In all such cases the bile was practically normal. In other cases, and these the majority, the effect of bile entrance was evident in a definite oedema and swelling, with slight induration of the organ. In these, on microscopical examination, one may find all grades of necrosis, diffuse or localized, involving a few acini or whole lobules, the individual cells showing early stages of degeneration—a diffuse "cooked" appearance, or advanced stages of mass necrosis together with marked oedema and congestion. These observations are, I think, important

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from the clinical standpoint. We are all of us frequently troubled at operation to decide whether the pancreas, which upon palpation we think is somewhat enlarged, a little harder than normal, and nodular, is really the seat of a mild inflammation or is normal. The pathologists tell us that in such cases, upon the opportunity of a postmortem, they can find no evidence of pancreatitis, and clinicians of prominence warn us that we should be very chary of saying that there is actual pancreatitis present. In two patients, suffering from quite definite subacute pancreatitis, one of my own and one of Doctor Garrow's, a small section has been taken from the pancreas at operation for microscopical examination. Let me repeat that the pancreas to palpation was quite certainly enlarged and hard. In both the pathologist was of the opinion that there was no clear and definite pathological change present; yet in both I felt justified in concluding that there was clear evidence of pancreatic damage. In certain areas the cells were disintegrated, cell membranes broken, nuclei swollen, cytoplasm poorly staining, and in one or two places actually necrotic. There was also marked oedema and some congestion. I felt sure that these were not artefacts or due to imperfect technic, as the pathologist was inclined to believe, because I had seen the same slight lesions in association with absolutely definite lesions so many times in animals. I would, therefore, suggest that at least in many of the cases in which, at operation, we feel that the pancreas is *probably* swollen, it really *is* swollen; and that this effect is due to the entrance of small quantities of bile not seriously infected, and constitutes a warning that the biliary system must be freed of all possible infection.

The second part of the problem concerns the question of the *vis a tergo*. It is probable that before pancreatitis of any severity can be caused, there must be an increase of pressure in the expelling forces of bile. A number of investigators (Doyon, Freese, Mann, Bainbridge and Dale) have investigated the contractile force of the gall-bladder in animals and give figures approximating 150 to 225 mm. of water. An exact estimation is difficult, and they were concerned only with the normal animal. It is probable that in the human, and under pathological conditions, the contracting force of the gall-bladder may be much increased. Dr. F. N. G. Starr reports the following very remarkable observation. During operation on a patient suffering from cholecystitis with stones, under very light anaesthesia, he inserted his finger into the neck of the gall-bladder and immediately found it grasped apparently by a very strong muscular contraction, so strong that, as he puts it, he would have pulled the whole liver out if he had exerted his strength to pull his finger out. It was apparently a severe reflex spasm in the semiconscious patient. It may be that, if we were not accustomed to operating under full ether anaesthesia, we might encounter the same experience upon occasion. In any case this observation seems to me to have a direct bearing on the question. If, as the result of the stimulus of stone and inflammation, the gall-bladder is able to contract violently, we are immediately provided with the driving force needed to push bile into the pancreas. In my experiments

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it has been, as a rule, necessary to fill the gall-bladder more or less rapidly under pressure, or to give it a few squeezes, in order to stimulate the sphincter to contract and offer the requisite resistance. The normal contraction of the gall-bladder is undoubtedly feeble, and, according to Meltzer's law, the sphincter presumably relaxes at the same moment, so that ordinarily bile is not forced into the pancreas.

Another observation, which I owe to Doctor Mann, is that upon any sudden descent of the diaphragm with fixation of the abdominal walls, as in sneezing or vomiting, the pressure in the gall-bladder is driven up to a great height. This also might have some bearing on the question.

In three animals I have tried the effect of eserin hypodermically, and of barium chloride painted on the surface of the gall-bladder. In no case did I observe any peristaltic movement in the gall-bladder wall, although with a very high dose of eserin there seemed to be a slight tonic contraction of the gall-bladder as a whole.

With regard to the third factor, the abnormal resistance of the common duct sphincter, I have nothing new to add. One thing seems definite, that acid in the first and second portions of the duodenum will cause a temporary spasm of the sphincter. The contents of the duodenum have in the last few years been frequently examined since the use of Einhorn's tube has become general, and I understand from Doctor Einhorn (verbal communication) that sometimes he has found the duodenal contents to remain acid for a certain time. Whether one should, in cases of duodenal ulcer, or of the gastroduodenitis of the alcoholic, expect such a condition to be frequently present I do not know, but at least such an assumption is not unlikely, and in that case one might expect a recurring spasm of the sphincter; and this might serve to explain the frequency of pancreatitis in association with ulcer and alcoholism. This must still remain a matter of speculation. In any case, so far as my experiments go, it would seem that the more important factor in stimulating the sphincter to resistance lies in a sudden rise of pressure from the gall-bladder side, rather than in irritation from the duodenal side; and in this connection I am inclined to believe that the reason why a cholecystectomy is apt to cure coincident pancreatitis, lies partly in the fact that the only serious muscular contractile force in the biliary system has been cut out, and partly, also, in the fact that with the removal of the gall-bladder there is also removed the source of infected bile, at least in most cases.

SUMMARY

1. Infected bile, aspirated from the inflamed gall-bladder, exercises a much more severe necrosing and inflammatory effect upon the pancreas than does normal bile.
2. Chemical investigation of infected bile has not yet proved that this difference of effect is due to an increase in concentration of the bile salts as the result of bacterial action on the bile.

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3. Mild grades of pancreatic swelling, as estimated clinically, are certainly possible, and are represented by oedema with early necrosis of the parenchyma, presumably the result of bile invasion. The clinical statement in operation records as to the presence of "a somewhat thickened and indurated pancreas" is probably a correct interpretation of fact in most instances.

4. The gall-bladder, under conditions of irritation from stone or inflammation, is probably able to go into strong muscular contraction, and the hypothesis is set up that such contractions may provide sufficient driving force to cause invasion of the pancreas with bile.

5. The common duct sphincter is provoked to resistance not only by an acidity of the duodenal contents, but also by a sudden distention of the common duct through abnormal and unexpected rises of pressure in the gall-bladder.

¹ Archibald: Experimental Pancreatitis, etc., *Surgery, Gynecology and Obstetrics*, June, 1919.

DRAINAGE OF ABSCESS OF PANCREAS*

BY ALBERT J. OCHSNER, M.D.
OF CHICAGO

THE object of this paper is to direct attention to a very simple and safe method of draining an abscess located in the tail of the pancreas. The history of the case in the management of which this form of treatment suggested itself is not of sufficient interest to warrant its publication in full.

A woman, forty-eight years old, with symptoms of ulcer of the greater curvature of the stomach, which later proved to be malignant, was subjected to an exploratory laparotomy which demonstrated an indurated mass 5 cm. in diameter in the posterior wall of the stomach attached to the tail of the pancreas, which was swollen to the size of an orange, about 10 cm. in diameter. This swelling was congested and contained fluid. Evidently an abscess had formed in the tail of the pancreas from an infection originating in the perforated gastric ulcer.

In order to determine the condition more perfectly, an opening was torn in the transverse mesocolon and the abscess was found strongly adherent to the posterior wall of the stomach while the posterior wall of the pancreas was quite free. Great care was exercised in the manipulation of the pancreas not to rupture the abscess. An incision was then made in the left flank, immediately below the last rib, 5 cm. long, and a pair of forceps passed forward, guided by one hand, in the abdominal cavity to a point behind the pancreas. The blades of the forceps were spread widely open in order to establish a broad passage. The space behind the pancreas was then loosely packed with gauze, in the middle of which was placed a large rubber drainage tube. The gauze and the drainage tube were passed out of the wound in the flank and two cigarette drains were added and carefully placed behind the pancreas. The tear in the mesocolon was then repaired and the abdominal wound was closed. Five days after the operation the abscess broke spontaneously and a large amount of thick pus escaped. The gauze and the cigarette drains were removed gradually. The rubber tube was left in place for two weeks, when the discharge had been greatly reduced. The tube was then removed and the wound healed in two more weeks.

In case the abscess had not opened spontaneously it could have been opened safely after adhesions had been formed around the gauze tampon by passing long dressing forceps through the large drainage tube into the abscess, when the tube could have been pushed forward into the cavity of the abscess. The method is so simple and safe that it seems worth bearing in mind.

* Read before the American Surgical Association, June 15, 1921.

TRAUMATIC PANCREATITIS*

BY H. BEECKMAN DELATOURE, M.D.
OF BROOKLYN, NEW YORK

ABDOMINAL traumatisms are accompanied by injury to the pancreas in only a very small proportion of cases. Stuart (*Northwest Medicine*, March, 1921) gives a review of the literature to date with a bibliography of fifty-four cases, including one of his own. This list does not contain cases of perforating wounds in which the pancreas was involved. It is probable that the reported cases do not include all in which the pancreas was involved. Some have either not been reported or have not been recognized.

In thirty years continuous hospital experience in two hospitals, where the daily number of severe accidents is large, the case here reported is the first in which we have observed injury to the pancreas.

In some of the more severe cases of abdominal injury in which death followed in a few hours and neither operation nor autopsy was performed, pancreatic injury may have been present. In the cases subjected to operation involvement of the pancreas was not observed and in the non-operated cases the symptoms were not suggestive of this condition.

Penetrating abdominal wounds are not frequently accompanied by injury of the pancreas, according to published statistics. Surgeon General Wallace (*Lancet*, 1917) gives only five cases of injury of the pancreas in a total of 965 penetrating abdominal wounds reported, and in 300 cases collected by Fraser and Drummond (*British Medical Journal*, March, 1917) only one involved the pancreas. The following record gives the details of the one case which has come under my observation:

CASE.—*Subcutaneous Laceration of Head of Pancreas.* Operation; Pancreatic-pseudo-cyst operation, recovery. C. S., school boy, aged thirteen years, was admitted to St. John's Hospital, Brooklyn, November 21, 1919, at 1.20 P.M. He had been knocked down by a wagon, the rear wheel of which passed diagonally over the body from the right thigh upwards and to the left across the body to the lower left ribs. There was moderate shock and complaint of pain in the upper right thigh and also in the epigastric region.

He was a well-developed boy, with slight skin abrasion at the upper part of right thigh and slight ecchymosis across the abdomen. There was no distention of the abdomen; no muscular rigidity; moderate tenderness on pressure in epigastric region. No dullness in either flank. Both testicles were drawn up into the inguinal canal. No symptoms of internal hemorrhage. Symptoms of shock slight. Urine analysis negative—no blood present.

Just after admission he vomited a large amount of undigested food; following this pain was much relieved. Temperature, 98.6° F.; pulse, 80; respiration, 30.

During the first twelve hours the patient complained at intervals of severe pain. Vomited a bile-stained fluid at frequent intervals. After each attack of vomiting pain would disappear. During first eighteen hours, hourly records gave

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pulse 92 to 96; temperature, 99° F.; and respirations, 32. During this period the only symptoms of note were the persistent vomiting and recurrent attacks of quite severe pain. The question of internal injury was carefully considered, but with so little shock and no evidence of hemorrhage, it was considered best to carefully watch the symptoms before making an exploration.

The following morning the patient was seen by me. At this time there was no abdominal distention, moderate rigidity of the recti above the umbilicus and tenderness in epigastrium. At this time there was evidence of fluid in the abdominal cavity. Temperature, 100.5°. Pulse, 100. Vomiting still continued at short intervals. It was evident that there was some abdominal injury. A tentative diagnosis was made of either rupture of the liver with moderate hemorrhage or contusion or laceration of the mesentery with hemorrhage.

Operation twenty-four hours after receipt of injury. Incision to right of median line in upper abdomen. On incision of the peritoneum there was an escape of considerable blood-stained fluid and a few blood clots. There was no evident injury to small or large intestine, spleen or liver. In the region of the duodenum the entire area was very edematous and blood stained. On further exploration the head and about one-half of the remainder of the pancreas was found lacerated and contused. The pancreas was exposed through the lesser omentum and three iodoform cigarette drains carried down to the injured tissue. The drains were brought out through the original incision and the wound closed in layers. During the exploration very extensive areas of fat necrosis were observed in the omentum.

Although the operation was not a prolonged one and there was no excessive bleeding, the shock following was very marked. The pulse became 136-150 and very weak, and so continued for twenty-four hours. The temperature the first night reached 103° F., and the following noon 103.8° F., pulse 130, and respirations 40. There was extreme restlessness and thirst. A profuse sanguinous discharge from the drains was extremely irritating to the skin.

November 24th: Much less restless and thirst has disappeared. Abdomen slightly distended, moderate amount of pain and no vomiting since operation.

November 26th: Temperature 99.8° F., pulse 100. General condition good. Has vomited once, milk stained with bile.

November 29th: Has been complaining of hunger. Given soft diet, which was taken with relish. Normal bowel movement. Temperature 99°, pulse 80. Iodoform drains removed. Much irritation of skin about wound.

December 3rd: Very little discharge, all drains removed. Complains of pains in epigastrium, especially at night. Is very restless and vomited greenish fluid during the day.

December 9th: During the past days has complained a good deal of pains in the epigastrium, especially at night, and after eating. Abdomen slightly distended, particularly in the epigastrium. Enema given with satisfactory result, but without relief of pain. Has vomited at intervals. Is very irritable and restless.

December 10th: Temperature suddenly rose to 102.4° F.; patient was very restless and vomited twice during the day. No local abdominal findings. Partial obstruction of bowels by adhesions was suspected.

December 23rd: Since last note there has been some improvement in the general condition, vomiting only occasionally, and pain usually quite severe each night. Has been out of bed part of each day during the past week. Has felt better and is hungry. There have been occasional attacks of abdominal pain, but not as severe. Has vomited only once or twice. Today, following an attack of intense abdominal pain, the temperature suddenly went to 102.6° F. There was some abdominal distention and tenderness over pancreatic region.

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January 4, 1920: Since last note the temperature has continued between 99° and 101°. He has been very comfortable during the day, but during the nights has had severe attacks of pain that cause him to cry out. During the past two days a swelling has been evident in the epigastric region and has enlarged rapidly. Blood count: leucocytes, 27,000, polymorph, 85 per cent. Vomited a large quantity of dark green fluid once each day for three days.

January 5th: Leucocytes, 21,000. Mass in upper abdomen much larger. Pains still continue. Diagnosis of pancreatic cyst made and operation advised.

January 6th: Incision made in back just below twelfth rib, two inches to the right of spine. Through this the posterior abdominal wall was opened and the mass was found just internal to the upper pole of the kidney. This was incised and about three pints of clear fluid evacuated. A drainage tube was inserted and the wound closed about it.

January 8th: Patient's condition improved immediately after the operation. Pain and vomiting have ceased. There has been a profuse discharge through the drainage tube.

January 19th: Marked improvement in general condition; discharge continues. Tube removed.

January 23rd: Out of bed. No further drainage. There has been a marked increase in weight during the past week.

February 6th: Discharged from hospital.

May 1, 1921: General health has continued to improve. There has been no recurrence of the symptoms.

The points to be noted in this case are:

1. The comparative absence of shock, although over one-half of the pancreas was badly contused and lacerated.

2. The principal symptoms, both during the first hours after the injury and during the stage of development of the cyst, were vomiting and severe upper abdominal pain occurring at intervals. In each instance these were immediately relieved by operation. Emaciation was marked until after the cyst was drained, although the boy was eating well most of the time.

3. The ease of approach from behind and the better drainage obtained.

Stuart, in his paper, reports a case of subcutaneous injury to the pancreas due to a direct blow on the upper abdomen. In this case dyspnoea was a very marked symptom. Persistent vomiting and pain were also present.

R. A. Stoney (*British Medical Journal*, April 13, 1918) reports a case of pancreatic pseudo-cyst following a shell wound of the abdomen ten months before. Complete recovery after drainage.

Morley (*British Medical Journal*, March, 1918) reports the case of a private hit in the back by shell fragment July 24, 1916. There was no evidence of peritonitis, but severe aching pain in the epigastrium. Two weeks later a swelling appeared in the epigastrium with rapid loss of flesh. Temperature, 99.4° F.; pulse, 100. Three weeks after injury operation was performed through an anterior incision exposing a fluctuating tumor in the lesser sac. The anterior wound was closed and the cyst opened by an incision from behind below the twelfth rib on the left. About four pints of clear fluid evacuated. Recovery slow.

C. A. Roeder (*Nebraska Medical Journal*, January, 1920) states that in

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forty-seven cases of pancreatic cyst twenty per cent. gave a history of abdominal trauma.

The pancreas is occasionally injured during operation on other organs. While performing pylorectomy a portion of the pancreas may be removed in making a wide dissection. I have had two such cases without any harmful result.

Young (*Journal of Urology, 1917*) reports two cases of injury to the pancreas during nephrectomy. He states this is more liable to happen on the right side because the head of the pancreas is more fixed and approaches nearer the suprarenal body. In one case death occurred on the fourth day and autopsy showed fat necrosis and acute pancreatitis. This was evidently due to the application of a clamp to secure bleeding at the bottom of the wound. Young says we should suspect such a condition where the operation is followed by rapid prostration and extreme distention.

Stuart, in his review of cases of subcutaneous injury to the pancreas, cites forty-six cases in which the results are known; thirty-eight were operated, out of these twenty-seven recovered and twelve died. In several of the reported cases where operation has been performed the stomach has been described as being pressed forward and spread out over the cystic tumor. In each of these cases had aspiration been resorted to the needle would have passed completely through the stomach before entering the cyst. Aspiration should never be employed in tumors of the upper abdomen.

In conclusion, we would direct attention to the posterior incision as being the simplest and most direct method of reaching and draining cysts or abscesses of the pancreas. If the diagnosis is not made before exploration then as soon as the condition is clear it is better to close the anterior incision and approach the tumor through an incision parallel to the lower border of the twelfth rib of the side on which the tumor is most prominent.

CHRONIC CHOLECYSTITIS WITHOUT STONES: DIAGNOSIS AND TREATMENT*

BY WILLY MEYER, M.D.
OF NEW YORK

SINCE patients with affections of the bile tract have become borderland cases, the operating surgeon has often been disappointed, when cutting down in the quiescent stage of the trouble upon the gall-bladder of a patient who had gone through a number of colicky attacks in the right side of the upper abdomen, to find a seemingly normal, soft, bluish and glistening organ, not harboring stones, nor presenting any adhesions whatever.

No doubt many a surgeon, knowing and finding stomach and duodenum not to be the seat of the trouble, even to-day reluctantly removes the appendix in such a contingency and then, leaving the other organs intact, closes the abdomen; or, if the appendix had been removed at a previous operation, he considers the present interference a disappointing exploration and desists from further investigation.

But the patient does not get well.

Had, in a case like this, a more detailed examination been made, had *all* the diagnostic means which are at our disposal to-day, been exhausted previous to the operative interference, the probabilities are that they would have given an indication for a procedure that would have been helpful to the patient.

I. *Diagnosis*.—On trying to analyze a patient's complaints of frequently recurring, or more permanent, pain in the upper abdomen, the physician whose advice is sought, will primarily think of disease of the stomach, duodenum, gall-bladder, or pancreas; secondarily also of the appendix and kidney.

A most carefully taken and minutely exhaustive history of the case and an equally thorough clinical examination will pave the way for a preliminary diagnosis. For an intelligent differentiation the laboratory then has to step in.

Determination of the quantitative and qualitative acidity of the gastric contents, string test with the use of the duodenal bucket, examination of the faeces, Wassermann test and radiography with fluoroscopy will usually enable us to determine the presence or absence of gastric or duodenal affection.

Local tenderness and retention of part of the bismuth or barium meal at the end of twenty-four hours within the appendix, as shown by the X-rays, point to an affection of this organ. Its definite inclusion or exclusion in the diagnosis has gradually become of less importance in complicated troubles, since the majority of surgeons nowadays remove the organ in every

* Read before the American Surgical Association, June 15, 1921.

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case of abdominal incision, except the general condition of the patient forbids this addition, or adhesions bind the appendix down so firmly that it cannot be pulled into the wound. Even then, many of us, in order to take advantage of the anaesthesia, quickly add a special incision in the right lower quadrant, and thus free the patient once for all from the possibility of appendicular disease.

The history, repeated urinary analysis, stereoscopic X-ray picture and, if indicated, cystoscopy with ureteral catheterization and pyelography will usually clear up the question as to the presence of surgical renal disease, particularly of a stone, in the greatest number of cases.

In the course of the last years the diagnosis of pancreatic affection has been greatly refined by the examination of the duodenal contents. If all three ferment: amylase, trypsin and chymotrypsin are found, and in sufficient quantities, serious pathologic changes can be excluded.

For the determination of the presence of gall-bladder disease by means of laboratory findings, radiography, cholesterol test of the blood and examination of the duodenal contents with the help of the microscope as well as by chemical analysis and bacteriological culturing are at our disposal to-day.

Radiography.—At the last meeting of the American Gastro-enterological Association, at Atlantic City, May 3 and 4, 1920, A. W. George, of Boston, created quite a stir by maintaining that the healthy gall-bladder does not show on the plate under ordinary conditions; therefore, if the X-rays demonstrate a distinct outline of the gall-bladder, without showing the presence of gall-stones, such a gall-bladder is to be considered pathologic. He believed that this test may be relied upon in about 90 per cent. of the cases.

This claim, if correct, would mean a valuable addition to our diagnostic capabilities as regards chronic cholecystitis without stones. In view of the importance of this matter, from a clinical point of view, I took occasion recently to obtain the opinion of five of the leading radiologists of New York City as well as of two not residing in New York, and the present attitude of Doctor George himself. I requested their answer to the following questions:

1. Does the visualization of the gall-bladder on an X-ray plate mean a pathologic condition of the viscus?
2. In what percentage of cases do you think radiology able, at the present moment, to visualize stones in the bladder?

A reply was sent by every one, for which I feel most grateful.

Looking the letters over with regard to question 1, it appears that of the eight specialists interrogated, three answered with a definite "yes"; three appear to lean toward answering the question in the affirmative; one replied "no"; one leans toward answering the question in the negative.

With reference to question 2, one considers it of relatively slight importance, compared with question 1; he is inclined to "put the diagram of the adjacent hollow viscera first; a visualized gall-bladder, particularly if altered in shape and density, second; and the direct detection of gall-stones, either positive or negative shadows, third. If all three of these are present, or even

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the first and second are present, he believes the X-ray diagnosis relatively certain."

One says "the demonstration of gall-stones depends chiefly on their amount of contained calcium. There are many ways of figuring percentages, but we are able to demonstrate only a small minority of gall-stones definitely and diagnostically." He adds as his belief "that in diagnosing disease either of the gall-bladder or appendix, the chief value of the X-ray is in excluding disease of the alimentary canal and genito-urinary tract."

One estimates the cases of gall-stones which are of sufficient density to produce characteristic shadows on the X-ray plate, under 25 per cent.; one, 32 per cent.; two, 50 to 60 per cent.; one, 85 to 90 per cent.; one believes that visualization depends on the thickness of the patients, so much so that in those who are not extremely heavy practically all stones can be visualized; while he estimates a positive result in very fat patients equals 30 per cent.

Hope is expressed by one that pneumoperitoneum can be simplified, which would increase the positive percentage.

The conclusion we can draw from the foregoing is that, up to this moment, the assistance which the surgeons hope will be rendered by radiography in the fixation of the diagnosis of cholecystitis without stones, is in its evolution, promising however assurance of great improvement in the near future. And with regard to cholelithiasis it appears that at present radiography in the hands of experts may be relied upon as a means of helping to clear up the cases of recurring or permanent pain in the upper abdomen, as far as the gall-bladder carrying stones is concerned, likely in about 30 to 50 per cent. of the cases.

I said advisedly "pain in the upper abdomen," and not pain in the right upper quadrant, because it is a fact that must be borne in mind that the subjective pain due to a diseased gall-bladder may be exceptionally confined to the left side of the upper abdomen, and may be noticed by the patient over the left costal arch and the left side of the chest only, radiating from there to the left scapular region and shoulder, at no time involving the right side.

Since paying strict attention to this phenomenon for the last number of years, I have noted with increasing astonishment how frequently patients, suffering from gall-stones, complain of spontaneous pain in the region of the sigmoid, let us say in McBurney's point on the left, not seldom also tenderness at this point. This observation has been made particularly in emergency cases sent to the hospital with the tentative diagnosis of intestinal obstruction. It is only on closer examination that the surgeon will be able to make out that an inflammation of the gall-bladder is at the bottom of the trouble, that he has to deal with a reflex nerve phenomenon—paralytic ileus—and not an organic obstruction.

Cholesterol Test.—Regarding the cholesterol test, I have made inquiries from a colleague who, for many years, has done original work along these lines. He writes that a blood cholesterol determination when properly interpreted "is of decided value in the diagnosis of cholelithiasis." He adds "as with any test of this sort, it is paramount to realize its limitations."

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Other authors think that the cholesterol test of the blood cannot be relied upon in the diagnosis of cholecystitis with stones, to say nothing of cholecystitis without stones.

In this uncertainty of laboratory assistance the analysis of the duodenal contents stepped in and has proven one of the greatest advances clinical medicine has made in the course of the last five or six years with reference to determining and segregating diseases of the stomach, duodenum, liver, gall-bladder and pancreas. Einhorn's duodenal tube has carried a bright light into the hitherto existing darkness as regards the more refined diagnosis of diseases of these organs, same as cystoscopy and ureteral catheterization did literally some thirty years ago in connection with diseases of the urinary system. The aspiration, siphoning out and examination of the duodenal contents has pushed the recognition of the pathological conditions of diseases in the upper abdomen—as well as their treatment—a tremendous step forward. It is inspiring to note the increasing interest the subject awakens everywhere, particularly among the younger generation of medical men. There is hardly a man on the house-staff, I fancy, of any one of our larger hospitals, who has not become an expert in handling the duodenal tube and examining the collected fluid, who has not become an ardent disciple and co-worker in the evolution of this fascinating branch of medical and surgical diagnostics.

At the present moment physicians and surgeons are busy trying to determine the best and most useful and reliable method of collecting the duodenal contents.

When Einhorn and I commenced our combined work along these lines some five or six years ago, Einhorn had used his tube for diagnostic purposes for several years; in fact, he invented the method in 1909¹ for the purpose of diagnosing pancreatic disease. Later on he made use of it also in a therapeutic way, particularly for the treatment of gastric and duodenal ulcer. Since then its scope has been expanded steadily. I will but mention the healing of a duodenal fistula by means of a long duodenal (intestinal) tube (five cases on record so far); the use of the intestinal tube in diseases of the lower intestinal tract; duodenal flushing in the treatment of the so-called thrombo-angiitis obliterans and other cases of tobacco-smoke poisoning—duodenal feeding in operations on the mouth, pharynx, throat, oesophagus, etc.

Regarding the collection of the duodenal contents, we consider it best to do it with the patient in the fasting condition. Einhorn's results of the examination of the contents thus obtained, covering a period of eleven years,² prove its advantages. With regard to the bacteriological examination of the contents Garbat has corroborated Einhorn's findings with regard to the best method of collection in every respect.³ With the metal tip of the tube twenty-six to twenty-eight inches (about 66 to 71 cm.) from the incisor teeth, the duodenal contents are aspirated early on the morning following the introduction of the tube. It is to be assumed that liver as well as gall-bladder—provided the cystic duct is not obstructed—are physiologically discharging

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some of their contents into the duodenum, in spite of the fasting condition. If, exceptionally, no bile is found on aspiration, the injection of a few cubic centimetres of warm saline solution suffices to make it appear. The tip of the tube lies in waiting right in front of or somewhat below the papilla Vateri ready to receive the bile as it is physiologically discharged into the duodenum; suction from without then forces it into the barrel of the syringe. Green, yellow, yellow-green or black-green color and turbidity of the bile, the presence of pus corpuscles, particularly when in clumps, a small number of cholesterine crystals, and frequently numerous bacteria, point, we believe, to cholecystitis without stones; an increase in the quantity of these admixtures, particularly of the cholesterine crystals when they are very big in size and mixed with calcium of bilirubin crystals, to cholecystitis with stones.

If the radiograph and cholesterol-test point in the same direction, such corroboration is, of course, gratifying.

Since the Fall of 1919, particularly since the last meeting of the American Gastro-enterological Association at Atlantic City, May, 1920, the investigations of B. B. Vincent Lyon, of Philadelphia, have been brought more conspicuously before the medical profession. There is, I believe, hardly a centre of medical investigation, hardly a hospital of standing in our States to-day, that is not actively and enthusiastically engaged in collecting and examining the differently colored bile as it is poured out of the common duct through Vater's papilla after the injection of 60 c.c. of a 25 per cent. solution of sulphate of magnesium into the duodenum. Lyon was the first to suggest this procedure for the segregation of the bile from the different sources, on basis of Meltzer's theory that a concentrated solution of magnesium sulphate, when injected into the duodenum, would relax Oddi's sphincter and also lead to a contraction and emptying of the gall-bladder in consequence of the physiological law of crossed innervation.

Lyon and his followers interpret the cycle of the changed color of the poured-out bile from dark yellow through black to light, golden yellow, as representing the contents of the common duct, gall-bladder and hepatic duct—bile A, B and C. At the present moment it seems that this interpretation is not tenable. Einhorn's most interesting and convincing clinical and chemical investigations have shown that the dark-green often black bile (the so-called bile B), as caught by continued siphonage by the examining physician, after the injection of the magnesium sulphate solution, *does not represent* the contents of the gall-bladder, but is discharged from the liver. It can also be produced by duodenal introduction of sulphate of sodium, pepton, glucose and some other substances. Moreover, the same phenomenon of the outflow of very dark bile after the injection of these different chemicals, can also be observed in patients whose gall-bladder had been removed previously, thus distinctly showing that the dark bile does not emanate from the gall-bladder. It seems to be a secretion of the liver cells, pressed into increased activity by the absorption of the chemical substances from the duodenum by way of the venous system into the liver proper. Einhorn thinks that the dark color

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is probably due to the production of iron through the acute destruction of red blood-corpuscles within the liver cells.⁴

A further, clear proof for the contention that the so-called "B-bile" does not represent the contents of the gall-bladder, is rendered by direct clinical observation. The bile, poured out of the common duct after the 25 per cent. magnesium sulphate instillation into the duodenum, *always* shows the same dark, brown-black color, whereas the gall-bladder content, if aspirated from the viscus during the operation, prior to cholecystectomy, is not in every instance dark-brown or black, but often green, green-yellow or greenish black, *viz.*, of the same color as ascertained before operation, on collecting the duodenal contents with the patient in the fasting condition.

To repeat, the definite and, as it seems, correct conclusion arrived at by Einhorn is, that the dark bile siphoned from the duodenum with Lyon's test, is not furnished by the gall-bladder alone, but also—if not principally—by the liver. Consequently the proper and advisable procedure for collecting the duodenal contents in order to prove disease of the gall-bladder is, to do so with the patient in the fasting condition, and not after the liver has been artificially whipped into overwork.

As stated above, reliable data for the diagnosis of cholecystitis have been collected in this way, which many times were proven correct by subsequent operation.

II. Treatment.—As in other diseases of the intraabdominal organs of the borderline class, the treatment may be either symptomatic or radical.

An individual of some means who suffers from chronic cholecystitis and is opposed to or for various reasons prevented from undergoing surgical interference, can visit Carlsbad, Vichy, French Lick or other spas of reputation, drink the waters there, and later at home continue the treatment, following a strict diet, often for life time, and taking care that he has regular bowel movements. Intermittent forced evacuation of the bile from the common duct by means of the instillation of the 25 per cent. magnesium sulphate solution through the duodenal tube, and auto-vaccine treatment on basis of direct bacteriological findings and cultures from the collected bile, may further contribute to the patient's well-being in the course of this conservative treatment. He may thus lead a fairly satisfactory existence and be able to hold in check the frequent, tormenting gastric hyperacidity. However, he is never sure of himself; at any moment, suddenly, unexpectedly and unprovokedly a new attack may strike him. And the attacks due to cholecystitis without stones are often just as severe as those due to cholecystitis with stones, being likewise connected with fever, vomiting and general malaise. If such a patient gets tired at last and wants to be cured or at least made as safe and comfortable as possible, the removal of the gall-bladder has to be advised.

A patient in moderate circumstances, afflicted with recurrent cholecystitis, should be differently advised and treated from the start. Knowing that the absence of the gall-bladder is well borne by the human system, cholecystectomy is here clearly indicated. And the advice to have the gall-bladder

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removed, may be given conscientiously and emphatically by the medical man, as it is an almost certain clinical fact, that the chronic cholecystitis without stones very frequently is the precursor of the chronic cholecystitis with stones. Expressed in other words, a certain percentage of these patients will probably pass into the condition of cholelithiasis. In order to make them well, and useful members of family and community, from an economic point of view, cholecystectomy should be advised.

With the examination of the duodenal contents added to the series of required laboratory examinations in every chronic case of abdominal pain, above as well as below the umbilicus, the additional presence of a cholecystitis will often be detected, where appendicitis alone would be diagnosed by those who do not practice the method.

Having recognized a chronic, recurrent gall-bladder inflammation to be present besides a chronic appendicitis, and, perhaps, the principal cause of the symptoms complained of, we do not proceed by the unsatisfactory method, still practised by many, of cutting down upon the appendix and then palpating the gall-bladder, to find out whether or not it contains stones, and if so, remove it only then. With the refined diagnosis before us, it will become our duty to cut down upon the gall-bladder first, and then pull up into the wound the caecum for the removal of the appendix. In this way we shall be enabled to inspect and palpate incidentally any other organ of the upper as well as lower abdominal cavity. With such preoperative, thorough examination and corresponding operation, a much greater percentage of patients with chronic, recurring abdominal disease will get well with the help of *one* operation, instead of two or more.

Personal work done in this direction and on this basis in conjunction with Doctor Einhorn, for the last five or six years, justifies the following.

III. *Summary.*⁵—1. Aspiration of bile from the living gall-bladder during operation having shown the same stigmata as that collected from the duodenum in the fasting condition, before operation, definite proof has been rendered that the examination of the duodenal contents, obtained by the duodenal tube, with the patient in the fasting condition, deserves confidence and is to be considered a reliable procedure.

It is no hardship for anyone to swallow the tube; with some little persuasion, the most sensitive patients will permit even a repetition of the procedure, should this become necessary.

2. A glistening, bluish, soft and non-adherent gall-bladder found during operation may be diseased and harbor pathologic organisms within its walls.⁶ These organisms leave their place of habitation at times and enter the gall-bladder contents, infecting the bile stored within, although this bile has left the liver and reached the gall-bladder in a sterile condition. Recurrent attacks of inflammation, varying in severity according to the degree of virulence of the bacteria, will be the immediate consequence.

3. The bile within the gall-bladder, though discolored and turbid, is often found sterile. This is explained by the bactericidal action of the bile as

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such, and the but occasional presence of active bacteria within the bile. Aspiration of a certain quantity of bile at a given moment during the operation may just strike a sterile fluid, which, at other times, may contain bacteria.⁷

4. In view of the fact that bacteria are frequently found in the centre of gall-stones, we can understand how it happens that cholecystitis without stones is the precursor of cholecystitis with stones.

Cholecystectomy in cases of cholecystitis without stones, therefore, clearly represents a prophylactic operation in many instances, and is of particular benefit to those who must get well in order to be able to earn their living.

5. It has been shown that the black fluid, furnished by the Meltzer-Lyon test, the so-called B-bile, as collected from the duodenum by siphonage through the duodenal tube, after the instillation of a 25 per cent. solution of magnesium sulphate, is mostly a liver product, representing the immediate effect of absorption of the injected substance upon the liver cells. The bile contained in the gall-bladder seems to play no important diagnostic rôle in the cycle of secretions, though frequently some of it will be admixed to the so-called B-bile.

Repeatedly direct visual inspection of the gall-bladder during operation, with the tube in place and the instillation of a 25 per cent. magnesium sulphate solution into the duodenum, has failed to show the slightest physical contraction of the viscus, the latter having been under closest observation of the author and his associates for more than twenty minutes.⁸

6. The Meltzer-Lyon test has therefore little, if any, value in diagnostic respects, but it promises to be of great importance in the *treatment* of diseases of the biliary system.

7. Chronic cholecystitis without stones is a much more frequent disease than has been heretofore believed. Clinically, it seems to take the same place in the upper abdomen as chronic appendicitis does in the lower.

Chronic appendicitis, on account of its treacherousness and eventual danger to life, when suddenly flaring up, is generally conceded to be a surgical disease requiring operation. It is no longer a disease of the borderland.

Chronic cholecystitis, as mentioned above, still belongs to the borderland. Though not as treacherous and deadly in its sudden attacks, as the inflammation of the appendix may be, it nevertheless often undermines the patient's health and should, therefore, as a rule require the removal of the gall-bladder.

If only drained temporarily, such a gall-bladder may become the seat of a recurrent inflammation at any time and without any known provocation; it may also harbor stones at a later date. A patient thus afflicted who will not or cannot submit to cholecystectomy, may then pass into a state of chronic invalidism. His gall-bladder represents the same type of infected focus from which absorption takes place intermittently—auto intoxication—as the tonsils, suppurating teeth and intestinal stasis do.

Cholecystectomy represents the radical cure, and should be advised after the laboratory analysis, outlined before, has established the refined diagnosis.

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It appears that cholecystectomy is as well borne by the human system as appendectomy. The mortality of the operation, done in the interval, is almost as negligible as that of appendectomy in the interval stage. Here, too, we may expect that 100 per cent. of the patients recover; some extraordinary and unforeseen something, beyond the surgeon's control, would have to happen, if the patient did not recover.

9. Regarding technic, the Perthes incision is favored by the author in the strong male patient in order to restore the abdominal wall to absolute perfection.

He also believes it to be to the best interest of the patient, in the course of cholecystectomy, to advance from the gall-bladder fundus toward the common duct. This will enable the surgeon to meet possible anatomical variations as regards the blood-vessel and cystic duct arrangement (Eisendrath), and will further enable him always to place the ligature of the cystic duct close to the common, thus preventing the later formation of a miniature gall-bladder, as some authors claim to have observed after extirpation.

Temporary drainage of the abdominal cavity after ectomy is considered an absolute necessity. Air-tight suture of the peritoneal sac means taking chances with the patient's life, as the ligature of the cystic duct may give way for unknown reasons a few days after operation, and the leakage of infected bile then cause peritonitis and death.

10. The principal technical advantage, accruing from the preliminary more refined diagnosis of diseases of the bile tract in the presence of gall-bladder—*combined* with appendicular disease, is the indication derived from it with reference to the place of the incision. Knowing *before* operation that the bile is pathologic, we will cut down on the gall-bladder and pull up the cæcum with the appendix, instead of cutting down on the appendix and then palpate the gall-bladder region, as done heretofore. In the latter instance the surgeon can but determine the presence or absence of calculi in the gall-bladder; he cannot feel pericystic adhesions, omental attachments, etc.

11. Inspection and palpation of the gall-bladder during operation must cease to render the only indication for cholecystectomy. The *quality* of the bile, determined systematically, with the help of the duodenal tube *previous* to operation and, if desired, the condition of the bile aspirated from the gall-bladder *during* the operation, must guide the surgeon in his decision of where to incise and what to excise.

Many important questions, naturally, still remain unsolved and require further study, for instance:

Is the color of the normal bile always golden-yellow; in other words, does green or brown bile in a gall-bladder, or a mixed color always indicate pathology?

May the wall of a gall-bladder contain microorganisms, and the viscous still be considered non-pathologic? In other words, does the presence of bacteria in the wall of a macroscopically seemingly healthy gall-bladder *always*

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represent the first stage of the cycle of the pathological events up to the eventual formation of gall-stones?

Do the bacteria reach the viscus from the duodenum, or by way of the arterial blood stream, or the lymph current?

IV. *Final Results.*—A final follow-up of results obtained so far in our series of cases of cholecystectomy done for chronic cholecystitis without stones was started, but it has been impossible to complete it and, therefore, cannot be embodied in this paper.

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- ⁷ In order to obtain positive results of examination as often as possible, it is necessary to spread the bile on a culture medium immediately after aspiration from the bladder, or after incision of the gall-bladder in its aseptic condition directly after extirpation. It is further advisable to transversely divide the extirpated bladder which did not contain stones and place half of it into a 5 per cent. formalin solution immediately after extirpation for pathologic examination, and have the other half used without delay for tissue culture growth at the laboratory.
- ⁸ L. Aschoff and A. Bacmeister, "Die Cholelithiasis." Tena. G. Fisher, 1909.
- ⁹ Of course this kind of observation is not convincing, because physiological conditions are changed. A gall-bladder may act different with the abdomen closed.

SURGICAL MANAGEMENT OF GASTRIC ULCERS*

BY DONALD C. BALFOUR, M.D.

OF ROCHESTER, MINNESOTA.

THE surgical treatment of gastric ulcer is characterized by a striking uniformity of results. Averages based on statistics from scattered sources show that satisfactory results are being obtained in from 70 to 80 per cent. of cases of chronic gastric ulcers in which operation is performed. This average is considerably higher if we include patients whose distress has been alleviated only, so that the number failing to secure any benefit by surgical management does not exceed 5 to 10 per cent. It is this small percentage of absolute and relative failures, however, that the internist emphasizes and that the surgeon regards as a stimulus to increasing the efficiency of surgical methods.

Certain lines of investigation and action could be followed profitably in the endeavor to make the surgical treatment of gastric ulcer even more effective. The part of fecal infection in the etiology of the disease is of predominant importance, but a systematic, thorough search for an infectious focus has rarely been included in the surgical management. It is true also that the excellent results which follow operation for chronic gastric ulcer have been accomplished with little attention to postoperative dietary or therapeutic management, although it would be logical routinely to carry out an intelligent régime of diet and habits of living. Since these two unquestionably important phases in the treatment of gastric ulcer have been neglected almost entirely in the past, it seems safe to predict that with their full development the number of failures to secure a complete permanent cure will be still further diminished.

The point I wish to discuss in this paper, however, and one which I believe is of great immediate importance, concerns the selection of operation in cases of gastric ulcer. It is very probable that further progress toward maximum good results in this disease will come from the most intelligent selection and application of the methods of treatment which are now known, rather than from additional operative methods. It has become a platitude that the surgeon should have no fixed ideas of the operation he will perform in gastric ulcer until the lesion is revealed. The recent plea by British and European surgeons, notably Moynihan, for more frequent employment of partial gastrectomy for gastric ulcer indicates how unsettled is the question of the most efficient use of the various surgical methods of dealing with the lesion.

The observations in this paper are based on the results of the surgical treatment of 826 cases of gastric ulcer in the Mayo Clinic between January,

* Read by title before the American Surgical Association, June 16, 1921.

1913 and January, 1920, and they are intended to point out, as specifically as possible, the relative merits of surgical measures of proved value and some of the indications for their selection.

There are four main considerations upon which the value of any operation for gastric ulcer should be judged: simplicity, applicability, immediate results, and ultimate results.

Simplicity.—The simplicity of an operation depends on the ease with which it is performed and the soundness of the principles on which it is based. The popularity of gastroenterostomy is due largely to the fact that it excels in these two respects. Under ordinary circumstances the operation is simple and safe, and its chief purpose, affording rest to the stomach, is fundamentally sound. The value of the relative rest which is brought about by gastroenterostomy has not been sufficiently recognized, and yet it is probably the most important function of the operation. Absolute rest of the stomach can be secured by a jejunostomy, and Moynihan advocates and employs this procedure combined with gastroenterostomy in "Y" for very large fixed ulcers in patients in such condition that all other procedures are contraindicated; he reports excellent results of such management. The relative rest afforded by gastroenterostomy alone, however, seems to be quite sufficient, in all but exceptional cases, to create conditions favorable to the healing of the ulcer.

Another operation which stands out prominently because of its ease of performance is cautery excision; it also is based on sound premises, namely, the effect of heat on infected and malignant tissue. Inasmuch as it is now generally recognized that the best treatment for chronic gastric ulcer must include its radical removal, combined with some procedure to insure symptomatic relief and to prevent recurrence of the ulcer, it is fortunate that we have at hand such simple, safe, and effective measures as cautery excision and gastroenterostomy, the combination of which has been attended by such satisfactory results. Compared with these procedures, partial gastrectomy, particularly when combined with gastrojejunostomy in "Y" is primarily at a serious disadvantage, for the chances of mishap during its performance are too many to warrant adoption of the operation by any but the most skilled and experienced surgeons.

Applicability.—No operation compares with gastroenterostomy in its applicability, for often it can be employed when all other procedures are contraindicated, as in an extensively indurated, adherent ulcer high on the lesser curvature, for which resection is not feasible, excision unwarranted, or even destruction by cautery not easily carried out. Not only can gastroenterostomy be performed in such cases, but the results may be expected to be satisfactory in a large proportion of cases. The wide applicability of the operation and the likelihood of its bringing about good results has naturally led to its being performed when conditions definitely contraindicated it and especially when no ulcer existed. The extent of its abuse may be surmised from the fact that it has been found necessary to cut off a number of gastroenterostomies in the Mayo Clinic because the operations had been per-

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formed unwisely. When the operation is indicated there are fewer obstacles to its performance than to any other procedure. Even when the stomach is small and high-lying, and cannot be easily approximated to the jejunum, the anastomosis can be accomplished without undue difficulty. During the last seven years gastroenterostomy has been a part of the surgical management in 82 per cent. of the operations for gastric ulcer in the Mayo Clinic, excluding gastric resections.

Immediate Results.—One of the most remarkable accomplishments in the surgical management of benign lesions of the stomach has been the steady reduction of operative mortality. The elimination of former dangers directly associated with the operation, namely, hemorrhage, sepsis, and mechanical disturbances, has been largely responsible for the present low average mortality for all types of operation in all gastric ulcers, acute, perforating, and chronic, 2.99 per cent. This percentage has varied but little during the past five years, so that even with more effective preoperative and postoperative treatment and more careful selection of operation such improved methods affect the general mortality rate by only a small margin. The low mortality rate of 1.85 per cent. in 213 cases of cautery excision and gastroenterostomy in the Mayo Clinic during a period in which the indications for this operation were not so well known as they now are, is significant. On the other hand, partial gastrectomy for ulcer has been associated with a considerably higher mortality than that following knife or cautery excision and gastroenterostomy; but it should be stated that it has been the practice in the Clinic to resect the stomach only in cases of ulcer with serious complications or those suspected of malignancy. All operative procedures for gastric ulcer are so perfected now that the immediate convalescence of patients is rarely disturbed and serious complications, such as hemorrhage, vomiting, and mechanical difficulties at the anastomosis, have been practically eliminated.

Ultimate Results.—It is chiefly in relation to ultimate results that the plea for more radical surgical methods than gastroenterostomy is made, and the question is mainly whether or not the disadvantages of gastric resection, particularly its greater difficulty and its higher immediate mortality, are outweighed by any superior ultimate results which may follow the operation. Ultimate results may be considered under three headings: (1) relief of symptoms; (2) protection against recurrence of the ulcer or occurrence of a new ulcer; and (3) protection against the development of cancer.

Relief of Symptoms.—It is fortunate that the results of operation for gastric ulcer, so far as the relief of symptoms of which the patient complained is concerned, can be ascertained readily and accurately without reexamination of the patient. Certain points in connection with such results may be emphasized: (1) Experience has shown that if a patient has had complete relief for a year after operation, it is very unlikely that symptoms will recur, so that statistics and observations based on results after at least eighteen months are relatively accurate. (2) A point to which I have drawn attention in a previous paper² is that some patients, although completely relieved of their

symptoms, may suffer from gastric hemorrhages at a later period, this tendency being greatest in patients who have reported hemorrhages previous to operation. It is imperative, therefore, to deal radically with the bleeding type of ulcer, and since we have made a routine practice of destroying every ulcer, duodenal as well as gastric, associated with a history of bleeding, the incidence of these unexpected hemorrhages has been greatly reduced. (3) Of the patients who did not obtain a completely satisfactory result from the operation very few have not been accorded a greater and more lasting measure of relief than they had secured from any previous medical treatment. It is not difficult, if one seeks to find evidence that will appear unfavorable, to obtain statements from patients that they occasionally have some gastric disturbance following operation, which on fair consideration has no more significance than have similar disorders in persons in normal health. Such disturbances are cited, however, as evidences of surgical failures by those who endeavor to discredit surgery or to discredit a certain type of operation. The final judgment of what the operation has accomplished for the relief of symptoms can safely be based on the opinion of the patient.

Protection Against Recurrence of Ulcer, or Against Occurrence of a New Ulcer.—Gastrojejunal ulcer after gastroenterostomy, for example, has been so emphasized because of the numerous papers on the complication that a quite unjustified reaction toward this operation has resulted. It is apparently forgotten that ulcers occasionally recur and new ulcers occasionally form after any type of operation for gastric ulcer. Some known factors which contribute to the formation of ulcers in the line of anastomosis are the irritation of permanent suture material, unnecessary trauma caused by clamps or forceps, and a neglected haematoma. These are controllable factors, but the greatest advance towards preventing the occurrence of these new ulcers will be, I believe, the routine eradication of all septic foci and adoption of a proper postoperative dietary and therapeutic régime. The complete protection against recurrence of ulcers in any part of the stomach probably depends largely on the thoroughness of such measures.

Protection Against Cancerous Degeneration.—The danger of cancer developing on a gastric ulcer for which gastroenterostomy alone has been performed has been variously estimated. Kocher placed the figure at 2 per cent., von Eiselsberg at 4 per cent., while Coffey has found recently that in his own large experience cancer actually developed more frequently in cases in which excision was performed than in cases in which gastroenterostomy alone was performed; the latter incidence was only one in 163 cases. Our records show that in 214 cases of simple gastroenterostomy there were five patients in whom death from cancer occurred more than two years after operation. It must be remembered, however, that the percentage of late deaths following gastroenterostomy is higher than the percentage following

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any other operation. While it is not known how many in the former group die of gastric cancer, it is fair to assume, because of the absence of proof of the true character of the lesion at the time of operation, that a considerably larger number die of cancer than is known. One of the most interesting questions in this connection is whether gastroenterostomy alone, for an ulcer which has already taken on early malignant changes, does not, besides healing the ulcer, delay growth of the cancer cells already implanted. There is some evidence to show that this occasionally takes place, but very little evidence to support the view that cancer frequently develops on a really benign ulcer which has been gastroenterostomized. From all information we have been able to obtain on the subject, we have found that cancer has been known to develop, during a seven-year period, in thirty-three of the 799 cases of gastric ulcer in which operation has been performed in the Mayo Clinic. These known cases of cancer developed after every type of operation, and, what is of great importance, with apparently no less frequency following partial gastrectomy than following knife or cautery excision and gastroenterostomy. This whole question of subsequent results in relation to the different operations needs continued study. There is one certain fact, namely, that no operation for gastric ulcer will absolutely assure a patient that he will not die of gastric cancer. Whether the incidence of cancer after any operation which includes radical removal of the ulcer is any higher than the normal incidence of the disease remains to be settled and, if proved, explained.

This review of the relative merits of the various methods of dealing with certain types of ulcers and the attempt to establish indications for the operations are based on the experience with these methods in the Mayo Clinic, and a study of their immediate and late results.

Ulcers of the Lesser Curvature.—Ulcers of the lesser curvature, including those closely associated with the lesser curvature on the anterior or posterior wall, comprise almost 90 per cent. of all gastric ulcers. Small ulcers of the lesser curvature, that is, ulcers with craters less than 1 cm. in diameter, when situated in the pars pylorica or pars media, and without extensive induration or perigastric adhesions, have been best managed in our experience, from the standpoint of immediate and end results, by knife or cautery excision combined with gastroenterostomy. From the standpoint of operative management cautery excision has certain distinct advantages over knife excision; and the late results of cautery excision combined with gastroenterostomy, when the procedure has been wisely chosen, are at least as good as those obtained by knife excision and gastroenterostomy.¹ If either method of excision has been performed radically, the danger of cancer developing is negligible. The value of heat as a destructive agent to the cancer cell, which may already have been developed in the tissues surrounding the actual ulcer, has been well established. For small ulcers on the lesser curvature in positions less easily accessible, excision, preferably by cautery, followed by gastroenterostomy, is very satisfactory and as a matter of fact is the only radical treatment that can be carried out safely. Gastric resection is certainly not warranted

in these small, high-lying ulcers because of its technical difficulties, because the amount of healthy stomach removed is out of all proportion to the size of the ulcer, and because of the efficiency of cautery excision and gastroenterostomy. It may be doubted whether any method of surgical management of these smaller ulcers, in whatever position on the lesser curvature, will prove to be more successful than excision by cautery and gastroenterostomy, which give satisfactory results in more than 80 per cent. of the cases, and an operative mortality of only 1.8 per cent.

Ulcers of the lesser curvature with a crater larger than 2 cm. in diameter, with extensive induration, adhesions to neighboring structures and organs, and indications of possible malignancy, must be dealt with quite differently from the small, uncomplicated ulcers, to insure the best possible results. If a large ulcer is near the pyloric end of the stomach, pyloric resection is the operation of choice, unless the lesion is so fixed to surrounding tissues and is in such an inflammatory state that its mobilization is unwise. Under the latter circumstances gastroenterostomy is clearly indicated and it will give excellent immediate results with a fair prospect of permanency. The indications for subtotal gastrectomy become less clear the farther an ulcer of this type is from the pylorus, although as long as such an ulcer is reasonably accessible and can be mobilized safely, gastric resection is the best procedure. Beyond this point of reasonable accessibility, resection is inadvisable because of the reasons already mentioned, and because of the distinctly additional risk. When the lesion is in the body of the stomach and is associated with hour-glass deformity, resection in continuity is a useful technical procedure which will give good immediate results, but sometimes the ultimate results in our experience have been marred by disturbances in motility due to contracture in the site of anastomosis. Deaver and Pfeiffer have recently reported better results from this operation by adding a gastroenterostomy distal to the circular anastomosis.

The selection of the best operation for the small, uncomplicated ulcers and the large, complicated ulcers of the lesser curvature is not difficult. When an ulcer between these two types is met with on the lesser curvature, however, the best operation is not so easily chosen. Again the important question is that of malignancy. There are no hard and fast rules by which early malignant changes in an ulcer can be recognized, so that differentiation is not easy or certain, but it is a fact that the subsequent course of doubtful cases shows that errors in interpretation are rarely made and when they are it is much more likely that an ulcer has been erroneously labeled "cancer" than a cancer mistakenly called "ulcer." The danger of a primary gastric cancer or a cancerous ulcer being wrongly diagnosed or unrecognized by the combined findings of a well-qualified internist, a röntgenologist, and a surgeon, I believe to be most unlikely, and it is surprising how few of the gastric lesions diagnosed clinically, röntgenographically, and at operation as benign ulcers, prove to be malignant on pathologic examination following radical removal of the ulcer. The incidence of such cases in the Mayo Clinic

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has not exceeded one or two per cent. The method of removing a substantial slice from the ulcer and subjecting it to immediate microscopic examination, while not absolute in determining whether malignancy is present, has proved to be most valuable and is quite justified, providing the ulcer is immediately destroyed by cautery, whether or not malignancy is reported on pathologic examination. The procedure is carried out routinely in the Clinic in cases which really are not suspicious of malignancy, adding, of course, a gastroenterostomy. If, however, any part of the examination raises the possibility of malignancy, if the ulcer is favorably situated for resection, and conditions warrant it, partial gastrectomy holds first place, although the higher operative risk demands that the operation be well justified before it is attempted. The farther from the pylorus ulcers in this borderline group are encountered, the less definite become the indications for subtotal gastrectomy, particularly for the surgeon whose experience has not been large in this field. The best surgical management of these cases is, I believe, gastric resection when proof of malignancy is established; gastric resection, if it can be performed without an abnormally high mortality, when there is strong suspicion of malignant degeneration; radical cautery excision and gastroenterostomy, if the resection cannot be performed without an abnormally high risk; and, in all other cases, cautery excision and gastroenterostomy, except in cases of ulcer so near the cardia that access is too difficult, when gastroenterostomy alone will often give surprisingly good results. In cases of very extensive ulcer the usefulness of jejunostomy should be remembered.

Ulcers of the Posterior Wall.—After the lesser curvature the most common site of ulcer is the posterior wall: about 10 per cent. of all gastric ulcers occur there, and 75 per cent. of these are in the pars media. The surgical management of these is technically more difficult and is not as yet attended by as satisfactory results as follow operations for ulcers of the lesser curvature. Such ulcers usually have extensive craters and are attached to the pancreas, and the patients are often in poor condition. It is a requisite of any operative procedure undertaken for such ulcers that the stomach and pancreas shall be separated if good results are to be obtained. This separation may be accomplished by various approaches, such as transgastric, through the gastrohepatic omentum, or through the transverse mesocolon. W. J. Mayo has recently stated his preference for the gastrohepatic omentum route as the avenue of approach because it is simplest, most applicable, and most effective in exposing the ulcer and its attachments. The ulcer having been separated and specimens removed for microscopic examination, the edges of the opening in the stomach should be thoroughly removed by cautery, the raw surfaces of the pancreas seared, the opening in the stomach closed, and gastroenterostomy performed. If cicatrization has developed to a point in which there is hour-glass deformity in the body of the stomach and the ulcer itself can not be dealt with satisfactorily, sleeve resection combined with gastroenterostomy deals very adequately with the pathologic condition and with the deformity, although symptomatic relief is not certain.

When posterior ulcers are situated near the pylorus (only 8 per cent. of them are in this situation), pyloric resection is the operation of choice.

Ulcers of the Anterior Wall.—Ulcers of the anterior wall constitute only 1 per cent. of gastric ulcers. If the ulcer is small it can be excised primarily with the knife or cautery and direct closure made, or, if the ulcer is near the pylorus, a plastic operation may be advisable. The pyloroplasty of Finney has a definite application in small, non-adherent ulcers in close proximity to the pylorus, although its value seems to be chiefly in dealing with ulcers on the duodenal side of the pylorus rather than on the gastric side. The operation permits of radical removal of the ulcer and direct inspection of the posterior wall of the stomach and duodenum.

For large ulcers of the anterior wall near the pylorus, especially when they have perforated and become adherent to organs and structures, pylorectomy is justified if mobilization does not involve too wide a dissection into inflammatory tissue; but it should be remembered that these "pyloric" ulcers are almost always duodenal and hence not subject to malignant changes. The same indications for pylorectomy exist when malignancy is suspected or proved, as I have already pointed out. If pylorectomy is not advisable, gastroenterostomy alone, without separation of the ulcer from its attachments or any radical treatment of it, is the operation of choice. Should a diagnosis of malignancy or probable malignancy be made at operation and it seems unwise, because of the patient's condition or the condition of the operative field, to resect the growth, gastroenterostomy may be performed as a first-stage operation in anticipation of performing resection as the second stage when conditions are favorable. Nothing illustrates so well what gastroenterostomy will accomplish as its visible effect on these large, adherent lesions; and experienced surgeons all testify to the fact that when the abdomen is opened for the second stage, these ulcers, supposedly malignant, have occasionally entirely disappeared.

To the few remaining types of ulcers of the anterior wall and of the greater curvature the general principles that have been suggested may be applied.

The indications outlined for the choice of operation in gastric ulcers of various types and situations are necessarily somewhat general; but they are based on a careful study of the results of operations for 826 gastric ulcers in the Mayo Clinic during a seven-year period. It seems quite safe to conclude from these results that there is every justification for adhering to the practice of excising, preferably by cautery, the benign chronic gastric ulcer, and combining a gastroenterostomy with the excision. The results in this series of cases do not indicate that more radical treatment, gastric resection, is a preferable method in any considerable percentage of non-malignant ulcers.

It is encouraging to note in summarizing that we were able to trace 85 per cent. of the patients in this series. More than 70 per cent. report complete relief, 10 per cent. report marked improvement, and 4 per cent. only report no relief.

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THE ALTERED ANATOMY AND PHYSIOLOGY OF THE CÆCUM AND ASCENDING COLON, THE RESULT OF ADHESIONS*

BY GEORGE G. ROSS, M.D.
OF PHILADELPHIA

THE importance of adhesions involving the abdominal viscera in the causation of symptoms of various degrees of severity has long been recognized. In the past, however, these symptoms have often been discussed in a general way, and the results of abdominal adhesions have been often considered as consisting principally of indefinitely localized abdominal pain and more or less disturbance of the functions of the gastrointestinal tract. An exception to this viewpoint has, of course, always existed in those cases in which there has been acute obstruction of some portion of the intestinal canal.

Gradually, however, the fact has become established that the term "adhesions" is not sufficiently clear; that we must try to separate as clinical entities those groups of cases in which the adhesions affect principally the anatomy and physiology of a definite portion of the intestinal tract.

Moreover, I consider it to be established that adhesions involving the cæcum and ascending colon to such an extent as to cause symptoms can often, indeed, as a rule, be correctly diagnosed; that they give a distinct symptomatology, and that a definite line of treatment, surgical or otherwise, is indicated when such a diagnosis is made.

Any consideration of the treatment or symptoms of such derangements must rest upon a consideration of the variations from the normal anatomy and physiology of the parts affected, and upon certain factors concerning the nature and origin of the adhesions we have to deal with.

Normally the ascending colon is the largest portion of the intestine, the cæcum being its largest portion. In the majority of cases the cæcum has a freer range of motion than the other portions of the large gut, the ascending colon being, as a rule, fixed in the right iliac fossa and right kidney space. In but 25 per cent. of cases is there a distinct mesocolon for this portion of the intestine.

Physiologically, two points are to be noted as regards the ascending colon: (1) Its contents are semifluid or fluid and it is here that a large part of the water from the fecal stream is absorbed. (2) It is characterized by antiperistalsis, the wave being stopped by the closed ileocæcal valve. This reversed peristalsis has for its object the thorough mixing of the food contents before the withdrawal of the fluids. When the mixture is right, true peristalsis replaces the antiperistalsis, the food is pushed along to the transverse colon, and the ileocæcal valve opens for the admission of a fresh supply

* Read before the American Surgical Association, June 15, 1921.

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of material from the small bowel. It must be realized that in this lift of material alone, the individual being in the vertical position, considerable work is done by the musculature of the cæcum and ascending colon, and even a slight additional burden caused by pathological conditions may render normal function impossible.

The ascending colon, by its location, structure and function, is not much affected by acute inflammatory conditions arising within or from it. The mechanical effects of occlusion by neoplasm are well known and need not be discussed here. The most frequent cause of malfunctioning of this portion of the gut is adhesions. Excepting those cases in which we find adhesions within the abdomen following upon a definite infectious peritonitis—in which event the adhesions naturally correspond in location to the site of this process—the right iliac fossa is by far the most frequent site of those bands, folds and adhesions with which we are now dealing.

In a previous communication¹ I have laid stress upon the fact that these bands, folds and adhesions are, as a rule, not the result of faulty development or failure in the descent or rotation of the gut, but are inflammatory, caused by a peritonitis, acute or chronic, recognized or unrecognized, in adult life, infancy or the prenatal period. I believe that a recognition of this fact will do much to do away with the hesitation with which many surgeons approach the cure of conditions resulting from them, and with faulty surgical procedures which attempt an approach at correction from the wrong angle. The surgeon who deals with such adhesions must attempt to relieve symptoms due to them and to prevent their recurrence, not to reconstruct an intestinal canal according to his ideas of its physiology. Since these adhesions are, as a rule, inflammatory, they produce alterations of greater or less degree in a gut previously normal or nearly so. The inflammatory process causing them may have occurred at any period, and may not, indeed frequently does not, have symptoms severe enough to justify a clinical diagnosis of peritonitis. Its results are, however, of the same nature, if not the same degree, as those caused by a definite purulent peritonitis; *i.e.*, abdominal adhesions are distinguished from those possibly non-infectious agglutinations, transient in nature, referred to by certain authors.² In other words, the results involve destruction of the endothelial layer of the serosa, with subsequent formation of permanent pathological structures binding together certain of the abdominal viscera.

To approach correctly the treatment of such adhesions involving the cæcum (with the ileocæcal junction and the ascending colon), we must consider their grouping: (1) As to their extent and their location; (2) as to their anatomical effect by traction upon the abdominal viscera; (3) as to the systemic and local symptoms produced.

1. Since the degree of frequency and extent of the peritonitic process causing these adhesions varies so greatly, it follows that in a given case the adhesions may be of the slightest extent or so dense and extensive as to almost obscure the normal anatomy of the parts. Strange as it may appear,

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a few small adhesions may by their location cause a far more marked symptomatology than far more evident structures not so disadvantageously placed. Adhesions seriously interfering with the ileocæcal junction, causing fixation when the rest of the intestines in this region are ptozed, give probably greater distress than far greater structures obstructing only the cæcal lumen.

2. Adhesions about the cæcum and ascending colon do not necessarily give symptoms confined to these structures. They may cause interference with the gastrointestinal tract in any of its portions. We must consider among other conditions: (a) Malposition of the stomach associated with ptosis and fixation of the transverse colon, caused by adhesions; (b) traction upon the duodenojejunal junction due to adhesions in the ileocæcal area;³ (c) possible gastric lesions of an organic character superinduced by malposition caused by adhesions lower down;⁴ (d) traction upon the splenic and hepatic flexures by the misplaced transverse colon and fixed ileocæcal region.

3. Bearing in mind such conditions as these, we may approach a rational attempt at classification of the symptoms due to interference with the cæcum and ascending colon.

The local symptoms are: Pain about the ileocæcal junction and hepatic flexure, more or less constant with occasional marked exacerbations; tenderness, not localized to McBurney's point, but more diffuse; a feeling of actual stoppage of intestinal contents, *especially gas*, at the hepatic flexure. Fluoroscopic examination often displays a fixed point at the ileocæcal junction, hepatic flexure, or both, with delayed passage of intestinal contents. There is frequently a constriction, posterior displacement and fixation of the terminal portion of the ascending colon and hepatic flexure. Often there is an associated dilatation of the cæcum and first portion of the ascending colon.

As referred local symptoms, must be mentioned especially the gastric ones; *i.e.*, so-called dyspepsia without evidence of gastric disease, *but with tenderness in the right iliac fossa* often manifested, vomiting without gastric or upper abdominal cause and associated with fluoroscopic evidence of disturbed physiology of the cæcum and colon.

The functional symptoms are due to delay in the handling of the intestinal contents by the large gut—constipation, intestinal torpor and distress due to the excessive formation of gas and its slow and painful progress along the gut tube. The systematic symptoms are directly due to this coprostasis, with the excessive absorption of putrefactive materials. They may range from mere weakness, malaise and listlessness, cold feet and hands, and chronic headache, to the most extreme depression with secondary joint and other lesions due to what is practically fecal infection. Fortunately these severe cases are rare, for they are most intractable under any form of treatment.

It seems to me that careful study of a given case, and a consideration of the local and general symptoms, with careful X-ray studies, will in most instances enable us to make a correct diagnosis of cæcal (ileocæcal) and colonic adhesions.

Our ideas upon treatment should take just as definite a form.

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It can be broadly stated that the cases, insofar as treatment is concerned, fall easily into three groups:

1. Those cases in which the symptoms, due to a minor grade of adhesions, accompany a general ptosis of the viscera in individuals of the so-called "neurasthenic type." In these instances the difficulty caused by the adhesions is not the patient's major ailment. Attempts at surgical cure of such patients are rarely successful and have been in the past a cause of much unfavorable comment upon the surgery of intestinal conditions in general.

2. Those cases in which the adhesions themselves are the main or only cause of the symptomatology, giving rise to those local and general symptoms previously described. Either the local or general symptoms may predominate. If the local evidences are not marked, and the systemic effects are grave, careful study is necessary not only to demonstrate the cause of the general symptoms but also to eliminate those cases in which the intestinal lesion but accompanies other underlying factors.

3. Those cases with most severe general symptoms, in which the visceral conditions are such as to call for extensive surgical procedures—such as resection of the colon. Fortunately such cases are extremely rare. The primary mortality is high, and while there have been occasional brilliant results they have been so few as to discourage frequent attempts at such surgery.

My conclusions as to symptoms and treatment of the lesions under consideration are based upon the observation of a considerable number of cases.

I have been able to collect from various hospital services the records of thirty-six cases I have operated upon since I have made routine examinations for abdominal adhesions involving the colon and ileocæcal region whenever an abdominal operation is performed. The records are by no means uniform and it has been difficult to follow some of the cases. I have classified the thirty-six cases as follows:

1. Those in which the main pathological condition was an ileocæcal interference due to a Jackson's membrane or Lane's kink, with or without chronic appendicitis. There were nine such cases.

2. Cases more correctly to be classed only as "adhesions" involving the ascending colon and ileocæcal region. These were fourteen in number.

3. Cases in which a major surgical condition associated with those under consideration as also operated upon. These were three: one case of cholelithiasis; one case of salpingo-oophoritis; one high inguinal hernia.

4. Cases of abdominal adhesions (three classed as Jackson's membrane) in which the records were insufficient to permit of proper analysis.

Of the nine cases of Jackson's membrane in which adequate records were found, eight had an appendectomy performed at the same time, one had had an appendectomy four years previously with no benefit. In four of the nine cases a diagnosis of adhesions involving the ascending colon or hepatic flexure was made before operation; in two of these Jackson's membrane was definitely noted as a cause.

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Symptomatically the cases resembled each other in all having a history of abdominal pain. Usually this pain suggested perhaps appendicitis, subacute in type. An occasional patient (F. K. M.) would describe more in detail symptoms pointing to partial bowel obstruction and stasis rather than those leading to a diagnosis of inflammatory disease. One case had joint and toxic symptoms of long standing—these entirely relieved by the operation.

In eight of the nine cases a record of the ultimate result is at hand: six were cured (one still complaining of constipation); one (Mrs. Geo. I.) was benefited ("partially cured," September 30, 1920); one was benefited, but still seems to be in very poor shape. The operative recoveries in all of these nine cases were uneventful.

In all of the cases the appendix when still present was removed, the adhesions were freed, the surfaces covered with peritoneum where possible and swabbed with paraffin (or olive) oil.

There were fourteen cases of adhesions. Of these nine were cured with possible minor symptoms remaining; two were improved; one was unimproved; two died.

Among the cases much benefited (*i.e.*, cured) the following brief note of the pathology, symptoms and treatment may be given:

Pathology	Symptoms	Treatment
1. Sigmoid tied to lateral abdominal wall; chronic appendicitis	Upper abdominal	Appendectomy; release of adhesions.
2. Adhesions of omentum and almost complete obstruction of ascending colon; chronic appendicitis	.....	Appendectomy; release of adhesions.
3. Subacute appendicitis; subacute peritonitis; young adhesions RIF	Lower abdominal, plus nausea and vomiting	Appendectomy; release of adhesions.
4. Abdominal adhesions anchoring ascending colon and hepatic flexure; chronic appendicitis	Constipation	Appendectomy; release of adhesions.
5. Adhesions about head of cæcum; chronic appendicitis	Pain, right lower abdominal segment	Appendectomy; release of adhesions.
6. Adhesions (location); chronic appendicitis	Apparent attacks of subacute appendicitis	Appendectomy; release of adhesions.
7. Retrocæcal appendix; subacute; omentum constricting ascending colon, five years old	Attacks of appendicitis	Appendectomy; release of adhesions.
8. Previously operated; adhesion involving hepatic flexure and transverse mesocolon; anchoring stomach to right of mid-line	Generalized abdominal pain and pain on walking; constipation	Release of adhesions.
9. Previous operation; adhesions, ascending colon, duodenum and pylorus	Very general abdominal symptoms	Release of adhesions; rejection /R. broad ligament.

An analysis of these successful cases demonstrates that attention to the local pathology (appendicitis), etc., with release of adhesions only and meas-

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ures to prevent their recurrence, often results in a cure. It has not been found necessary to perform resections, plications or intestinal anastomoses. There can be no doubt that more extensive operations would have been associated with greater mortality—the results could hardly have been more satisfactory.

In the one totally unsuccessful case a dense band of adhesions involved the ascending colon, causing angulation and fixation. It is also noted that the stomach was passed to below the umbilicus. The patient developed a slight hernia through the upper angle of the incision. Nine months after the first operation she was operated upon by another surgeon—with what result I do not know.

Two cases of this series died: One with extensive colonic adhesions died of acidosis five days after operation. The second case died within forty-eight hours after operation. This patient was not in good condition before operation and had very extensive adhesions. She died with symptoms suggestive of peritonitis, confirmed at post-mortem examination.

In connection with those instances in which the adhesions are extensive and the gut has been kept from functioning normally for a long period of time, it may be noted that for a number of days immediately after operation the patient may suffer from symptoms suggestive of toxic absorption. The relaxed and poorly muscled intestine cannot propel the faecal material quickly enough and temporary stasis with excessive absorption of harmful materials takes place. When this becomes extreme an acidosis, perhaps fatal, supervenes. Measures to combat this possible condition should be undertaken immediately after operation in every instance. Sir A. Lane attributes some of these symptoms to interference with lymphatic channels formed within the adhesions and advises drainage after extensive operations even when the intestine is not entered.

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CARCINOMA OF THE LOWER PART OF THE SIGMOID IN A BOY FOURTEEN YEARS OF AGE*

BY INGERSOLL OLMS TED, M.B.

OF HAMILTON, ONTARIO

CARCINOMA of the large bowel in young persons is a rare condition. Louart¹ in 1900 collected from the literature only nine cases occurring in youths up to twenty years of age. Clogg² in 1908 collected seventy-two cases of cancer of the colon. The youngest of these patients was fifteen years of age.

Merkel,³ in his article of Tumors of Childhood in 1912, states that "The literature on the subject of malignant tumors in childhood must be accepted with some degree of caution since many of the cases lack histological confirmation."

Weinlechner in 5279 cases of carcinoma observed eighteen (0.34 per cent.) among children up to fourteen years of age. Feldner in 914 cases of carcinoma met with only three up to the sixteenth year of life.

Philip, in his inaugural dissertation on Carcinoma in Childhood (Munich, 1908), reviews the older and more recent literature. Among 390 cases collected by him only eighty-seven seemed sufficiently genuine to warrant consideration. Classified according to location and organs involved, he found the following regions to be entirely immune to carcinoma: lungs, tongue, esophagus, hypophysis (Erdheim, however, subsequently published two cases of malignant growth of the hypophysis), urinary bladder, penis, seminal vesicles, tubes, mamma. Merkel calls attention to the fact that the list comprises precisely those organs in which carcinoma in the adult is referable to chronic irritation.

The digestive tract was affected in 46 per cent. of the cases, and the sigmoid in only 5.4 per cent. In 111 cases, the large bowel was affected in 28, of these the sigmoid was involved in seven cases.

PARKINSON⁴ reports case of a boy, aged nine years, who died six months after onset of symptoms. No operation. The autopsy showed that the abdominal lump (*palpable intra vitam*) proved to be the sigmoid lying in the right iliac fossa and adherent to the adjacent small intestine. The wall of the sigmoid was thickened with a hard, whitish growth; the inner surface was ulcerated, no trace of mucous membrane remaining. The wall was one-third inch thick, the external surface was smooth. There was no constriction of the gut. Other organs normal.

Microscopic sections showed "large rounded and tailed cells packed in the midst of fibrous tissue alveoli. In some parts this is replaced by a granular, structureless, apparently colloid substance, taking the stain badly. It is, I think, a carcinoma."

* Read before the American Surgical Association June 14, 1921.

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The author also refers to a case observed in a girl twelve years of age.

BARBER⁶ reported a case of a boy of nineteen years. He was admitted to the hospital with symptoms of acute intestinal obstruction. Cancer history in the family, the mother having died of intestinal carcinoma.

The patient gave a history of intestinal cramps for one year, aggravated during the past two weeks, causing inability to work. He had always been constipated, but had no pain when the bowels acted. Two days before entering the hospital, the patient vomited persistently. There was no evidence of blood in the vomitus, or colonic washings. The abdomen was very tender, rigid and distended, especially on the left side and at the umbilicus.

A median incision disclosed a large indurated mass involving the upper extremity of the sigmoid. Above this mass the intestine was very much distended. There was very marked enlargement of the lymphatic glands in the mesosigmoid and upwards in the pre-aortic lymphatic glands. Complete excision was impossible. The tumor and regional lymph-glands were excised. An end-to-end union of the bowel was made. The patient recovered and left the hospital improved. A later report stated that he had lost weight and strength, which indicated that he was undoubtedly suffering from metastases. The pathological report was adeno-carcinoma.

PERSONAL CASE.—The patient, Gordon Smith, aged fourteen years, entered the Hamilton General Hospital on February 16, 1920, complaining of pains in the abdomen, frequent stools of blood and mucus, with rectal tenesmus. He gave the following history: About four months ago he began to suffer from irregular abdominal pains, sickness and nausea when taking his meals and frequent desire to go to stool. He lost flesh and the spasmodic abdominal pains became more frequent, and when at stool instead of passing fecal matter, only a little blood and mucus came away. This was always accompanied by spasm and pain in the rectum. At first the pains were more frequent during the day, especially so when eating his meals, but during the past few weeks he was compelled to go to the toilet two or three times during the night and the rectal tenesmus became more pronounced.

His family history is good. Both parents are living and healthy and there is no history of tumors or cancer in his family. With the exception of whooping-cough he has had no previous illness.

Present condition: He is a small, emaciated looking little chap weighing only sixty-two pounds. His face has a drawn expression, with wrinkles between his eyebrows. His heart and lungs are normal. The urine is negative to casts, albumen and sugar. The abdomen is distended and marked peristalsis is seen and felt in the transverse and descending colon. When his peristalsis comes on, the descending colon and sigmoid is shoved over to and even beyond the median line. After the spasm has passed off, a lump can be felt at the lower end of the sigmoid. On rectal examination, an irregular mass can be distinctly felt. The abdominal wall is so thin that the distended colon can be

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easily mapped out. The lad stated that sometimes when sitting on the closet, something seemed to come out of his anus.

It was somewhat difficult to decide the exact nature of the growth, as it hardly seemed likely that a boy so young would be affected with a cancer of the large bowel; yet, had this condition been seen in an adult fifty years of age, I would have had little hesitation in making a diagnosis of cancer. The patient had been in the hospital nearly two days before I saw him and as his condition was not very good, I operated immediately. The abdomen was opened and the growth was found at the junction of the rectum and lower end of the sigmoid. The bowel above the growth was very much distended with fecal matter. The rectum was likewise very much dilated and there was a partial intussusception of the tumor into the rectum. No enlarged lymph-glands were found and no nodules could be felt in the liver. Owing to the great mobility of the sigmoid and descending colon, the mass was easily brought well out of the abdominal wound and excised. The proximal bowel was so packed with a thick clay-like fecal mass, that it seemed wise to empty it before putting in a Paul's tube. The peritoneum was closed around the two projecting ends of the bowel and the skin and muscles approximated by a few sutures of silkworm gut. As the operation was not a lengthy one, very little shock followed. It was necessary, however, to remove the Paul's tube on the second day, as it became blocked with fecal matter. The wound became infected and the stitches were removed. The lad, however, was entirely relieved of pain, was able to take plenty of food, but did not seem to thrive. He became thinner and thinner. He was then taken to the roof of the hospital and kept in the open air. He improved immediately and gained flesh rapidly. The wound healed up around the divided ends of the bowel and on April 15th, nearly two months after his first operation, a junction of the two free ends of the bowel was made. This was, unfortunately, not quite a success, as a small fecal fistula developed, which, however, gradually closed, and he left the hospital on June 6th.

He has reported at my office several times during the last year and his weight has increased more than 50 per cent. His present health is excellent.

Pathological report made by Dr. W. J. Deadman, pathologist of the General Hospital, Hamilton, is as follows:

Gross Appearance.—The gross specimen consists of about seven inches of large bowel, in the centre of which is a cauliflower-like growth completely encircling the bowel and causing partial obstruction of its lumen. This tumor mass is raised about three-fourths of an inch above the general level of the mucosa, and is papillomatous in appearance. The bowel wall beneath is apparently infiltrated by the growth, although the peritoneal surface has not been broken through. In some parts of the tumor there seems to be production of mucoid material.

Microscopic Examination.—Histological examination of the tissue shows varied forms of atypical growth of gland epithelium. In

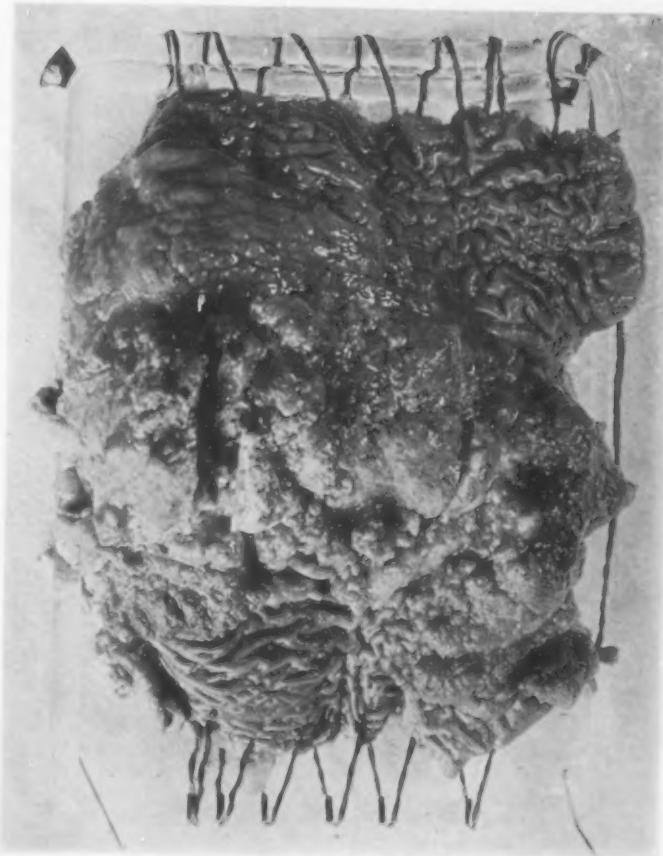


FIG. 1.—Carcinoma of Sigmoid, Case—Gordon Smith. One inch of the bowel above and below the tumor has been trimmed off in mounting the specimen, which on removal was seven inches in length. The width of the base of the tumor is two inches.



FIG. 2.—Carcinoma of Sigmoid, Case—Gordon Smith. H. P. field of section of tumor. Magnification X 10.

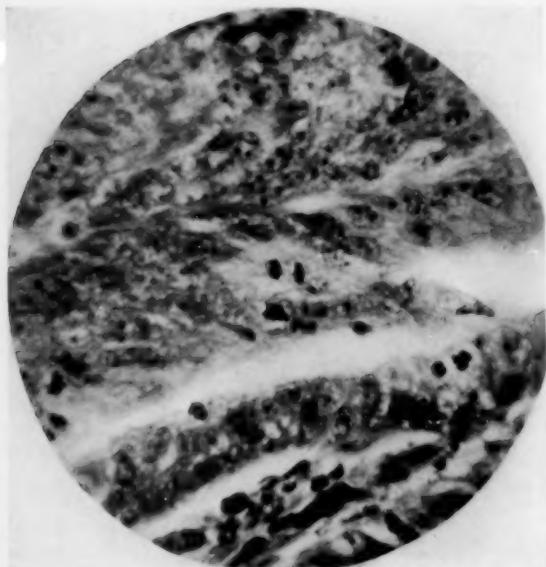


FIG. 3.—Carcinoma of Sigmoid, Case—Gordon Smith. Magnification X 400. Showing Mitotic Figures.

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some places there is an irregular formation of gland acini, many of which are lined by high columnar epithelium, while others show a marked heaping up of the epithelial cells. Some of these acini are distended and cystic, while in other places there is invasion of the underlying tissue by solid strands of epithelial cells. The interstitial tissue shows some areas of infiltration by polymorphonuclear leucocytes. In one area several epithelial cells are seen in mitosis. Diagnosis—adeno-carcinoma.

In patients where there is an old chronic obstruction the fecal matter above the obstruction becomes so thick and difficult to get rid of, that it will not go through a Paul's tube. In a number of such cases I have made use of a suggestion of the late Doctor McGraw, of Detroit. He mobilized the growth, brought the mass outside of the abdominal wound and placed his elastic ligature through the two healthy portions of the bowel above and below the growth. Instead of using his ligature, and where it is possible to milk back the contents of the proximal bowel, I make a similar anastomosis with sutures, remove the mass, close the divided end of the lower segment and leave the proximal end open for drainage. This acts as a safety valve and gradually contracts and is easily closed later.

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THE SURGICAL TREATMENT OF MEGACOLON*

BY CHARLES N. DOWD, M.D.

OF NEW YORK, N. Y.

It is nearly a century since Parry described a case of megacolon—observed at autopsy, in an adult who had suffered from digestive disturbance for years. This colon was enormously distended, and contained an immense quantity of faeces. We do not know what observations had preceded his, but between 1825, the date of his publication and 1886, the date of Hirschsprung's first article, there were at least twenty-six publications about these tremendously enlarged colons. Hirschsprung's articles stimulated attention to the subject and they came at a time when abdominal surgery and abdominal pathology were receiving increased attention, hence when Finney wrote his classical article in 1908 he found a bibliography of 206 articles. Since that time the literature has increased even more rapidly, and is now so large that it is hardly possible to grasp it in full detail.

Method of Occurrence.—Congenital idiopathic dilatation of the colon (Hirschsprung's disease) has generally been considered, in large degree, a disease of childhood. There are a great many descriptions of the disease occurring in children. They surely make the most vivid pictures. Hirschsprung advocated the name of "true" megacolon for them and the name of "pseudo" megacolon for those cases occurring in adults. With the later development of the subject this distinction has not always held. Many observers believe that if some patients with this disease can worry along to adolescence, others can reach adult life and that there is no proper age limit. The subject has been complicated by the including of reports of localized megacolon. Even in the undoubted congenital cases the sigmoid is more apt to show dilatation than the rest of the colon: the intestine angulates at the fixed points and distends elsewhere, although after its removal it may be as large at a point of former angulation as at a point of former dilatation: hence it is not strange that there should be many reports of localized megacolon. However, the custom of reporting such cases has led to the description of an increased number of adult cases, and an increased proportion of cases in whom the mechanical factor of obstruction predominates. Hence considerable confusion has resulted, and it is now impossible to differentiate in the literature those patients in whom the enlargement of the colon is due to a congenital defect from those in whom it comes from mechanical or spasmodic obstruction. We know, however, that enormously dilated and hypertrophied colons are observed in children, and that similar conditions are sometimes

* Read before the American Surgical Association, June 14, 1921.

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seen in adults; also that the adult cases in the main show greater evidence of mechanical or nervous obstruction as causative factors.

Pathology.—The degree of dilatation which these colons reach is almost beyond belief. Finney states that the circumference of the abdomen may be greater than the height of the patient and quotes Peacock as describing a colon which contained sixteen litres. Graves describes a colon 110 cm. long and 31 cm. in circumference in its descending portion. Bensandi and Sorrel describe one 26 cm. in circumference. Johnson describes a colon which contained three or four quarts of faeces. From the second case recorded in this paper at least one gallon of semifluid faeces were withdrawn on the operating table, and about another gallon drained away in the next two days. The removed portion of the colon in Case I easily held four litres of fluid after its removal. The walls of the colon are usually hypertrophied as well as dilated, especially in their circular muscular coats. The mesocolon may be lengthened and hypertrophied in all its elements. Obstructive valves have been described. Volvuli have been found. A few anal fissures have been described giving suggestion of spasmodic obstruction above.

Etiology.—There are three main theories for the etiology:

1. That it is due to congenital defect in the development of the colon.
2. That it is due to some form of mechanical obstruction, and that the colon hypertrophies and dilates in its efforts to overcome this obstruction, just as the heart hypertrophies and dilates when increased demand is made upon it.
3. That it is due to spasm of the circular fibres in the lower part of the intestine, and that dilatation of the colon follows this spasm just as dilatation of the oesophagus follows cardiospasm, or dilatation of the stomach follows pylorospasm.

It is altogether probable that two or more of these elements are active in many of the cases.

Symptoms.—The main symptoms are abdominal distention, constipation lasting sometimes for very long periods, intermittent diarrhoea, loss of appetite, emaciation, apathy.

The study of the treatment of the disease is the main purpose of this paper. Very careful consideration of its occurrence, pathology, etiology, and symptoms is given in other papers, particularly that of Finney to which readers are referred for such information.

RECORD OF CASES

CASE I.—E. F., aged ten and a half. The Roosevelt Hospital. History No. 16873 A. First seen by writer March 31, 1920. She had reasonably good health during the first seven years of her life, then loss of strength and listlessness. At eight and a half years irregular attacks of abdominal pain began, in epigastrium and on both sides. They were accompanied by constipation. Her disability progressed; by December, 1919, she had become a real invalid, taken about from one doctor to another in search of relief from her distress, weakness, pain, alternating constipation and diarrhoea and frequent micturition.

When admitted to the hospital she was found to be a thin, emaciated child of

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sixty-one pounds weight, and having a very large abdomen. The left half of the abdomen contained a large, rather soft, slightly movable mass. Enemas brought away an enormous quantity of faeces and the mass disappeared. No obstruction could be found in the rectum. X-ray examination after a barium enema showed a dilated sigmoid. (See Plate 1.) It was not found practicable to give enough barium mixture, either by mouth or rectum, to secure a picture of the entire colon in a dilated condition.

Operation.—After ten days of further treatment by medicine, diet and enemas an operation was done. A seven-inch incision was made through the inner part of the left rectus muscle; a greatly distended transverse and descending colon were immediately encountered. They seemed to fill the greater part of the abdomen and to push the rest of the intestines backward and to the right. The splenic flexure was held in position by its peritoneal attachment, the costo-colic ligament, and formed an acute angulation. The distention seemed largely due to gas.

The descending colon and the splenic flexure were mobilized by dividing their outer leaf of investing peritoneum. The mesocolon was then divided in sections from the lower sigmoid to the hepatic flexure. The liberated loop of intestine, somewhat over forty inches in length and four inches or more in diameter, was then drawn outside of the abdomen through an intramuscular incision which had been made for that purpose above the left anterior superior iliac spine. This brought the hepatic flexure into contact with the lower sigmoid without undue tension. The afferent and efferent intestinal walls were stitched together within the abdomen to aid in proper "spur" formation. The median wound was then closed and sealed. The intestine at the place of exit was secured to the abdominal wall. Temporary circular ligatures were applied to it outside of this exit and the loop of colon beyond the ligatures was ablated. The ablated portion was 95 cm. long and held four litres of fluid when injected.

She showed considerable shock and reaction after her operation, but finally rallied satisfactorily. The temporary circular ligatures were removed from the protruding stumps of intestine after forty-eight hours and a "double-barrelled" intestinal stoma was thus established.

The median incision healed by primary union. The clamping of the spur was begun after twenty-five days, and twenty-three days later the intestinal ends were stitched together at the site of the stoma.

She left the hospital seventy-eight days after the operation. At that time the stoma was firmly closed. She was having normal bowel movements; she had been walking and playing about the ward and the porch for two or three weeks; she ate well, had gained much strength, and five and three-quarters pounds in weight. The X-ray picture shown in Plate No. 2, indicates the condition of the remaining colon at that time.

She has been carefully followed during the intervening months. Her digestion has remained normal, and she has normal daily stools. She has gained twelve pounds in weight since she left the hospital, and is now a normal, active, happy, good-natured youngster.

An X-ray picture taken March 7, 1921, shows that the colon has about the same outline as when she left the hospital.

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Macroscopic (by Dr. W. C. White).—Specimen consists of a piece of large intestine 95 cm. long in transverse diameter, varying from 5 to 7 centimetres. The wall is thin, markedly dilated, pale and of atonic appearance. The mucosa appears normal and the specimen otherwise is unremarkable.

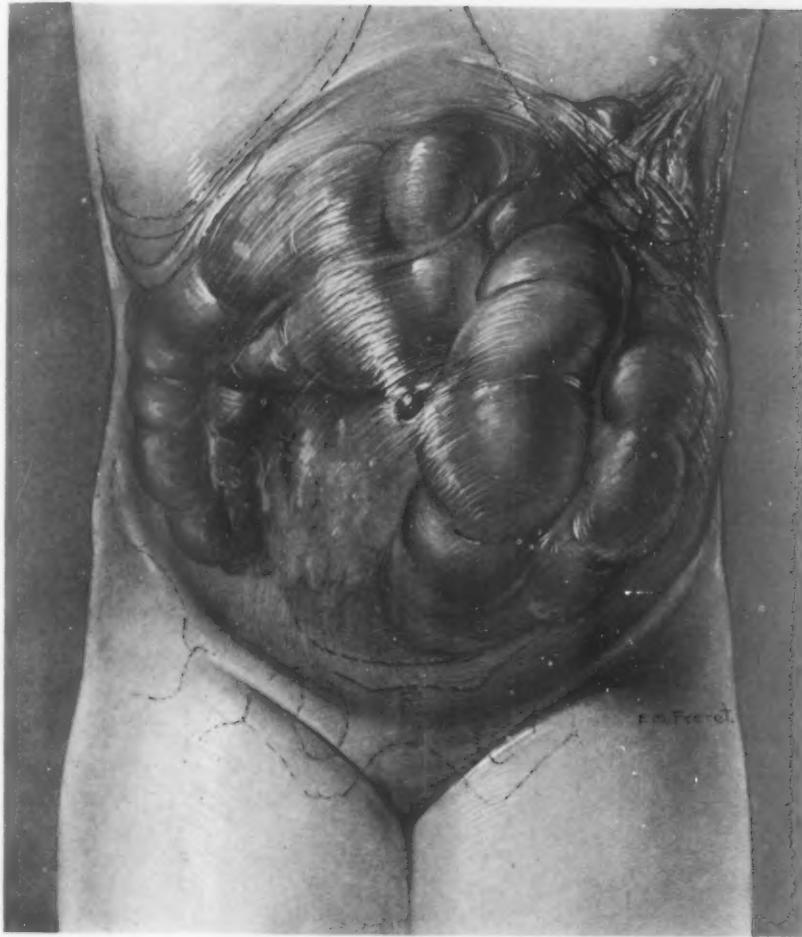


FIG. 1.—Diagrammatic drawing showing condition of megacolon in Case I. Colon angulated at splenic flexure. Transverse colon and descending colon and sigmoid flexure greatly distended.



FIG. 2.—X-ray picture after enema of barium mixture showing shadow of the descending colon and sigmoid flexure.



FIG. 3.—X-ray picture taken twenty-four hours after meal of barium mixture showing condition of colon three months after operation.

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Macroscopic.—The entire wall is very much thinned out. The mucosa is intact and shows no inflammatory reaction. The muscularis mucosæ is very thin. The submucosa consists of relatively loose tissue. The circular and longitudinal muscles are thinned out. The serosa is loose and shows no connective-tissue increase.

CASE II.—F. W., aged seventeen. Admitted to the Roosevelt Hospital November 6, 1920. History No. 17337 A. She had always been very constipated, has had three or four attacks of great abdominal distention and vomiting during her life. The last previous attack came six months ago; the distention then was almost as great as at the present time. She then had repeated vomiting and severe abdominal "cramps."

The present attack began three weeks ago with abdominal distention, nausea and vomiting. The distention increased and was accompanied by very severe abdominal pains. Repeated enemas had been given, but some of them at least did not return. The bowels, however, had moved two or three times a day much of the time. During the past three days she had many times vomited green offensive material. Had been in bed the entire three weeks and had become very weak.

On admission to the hospital she was emaciated, very feeble, pulse 140, abdomen enormously distended. The outlines of the intestine were visible through the thin abdominal wall, and slowly moving peristaltic waves could be seen. Enemas and rectal tubes were used in an effort to empty the bowel, but they were not successful. Operation was therefore done.

Through an incision in the lower part of the left rectus muscle an enormously distended sigmoid flexure was found. It was about as tense and thick-walled as an ordinary large ovarian cyst. It could be traced from the pelvis to the upper left angle of the abdomen, but satisfactory examination of the colon beyond that point was not practicable. A suction trocar withdrew semi-solid faeces. A purse-string suture was placed about the trocar wound. The abdominal incision was closed except an opening of one and a quarter inches; the intestine outside the purse-string was stitched to the edges of this opening, a flanged glass tube was introduced within the purse-string and secured in its position. About one gallon of fecal material was then drawn through the tube by a suction apparatus. During the following forty-eight hours about another gallon of fecal material drained away. The abdomen became flat, its circumference was reduced from thirty-four inches to twenty-six and a half inches.

For a few days she showed some recuperative power, but died on the sixth day after her operation, apparently with a low grade of pneumonia. She showed no signs of peritonitis. Autopsy was not allowed.

CASE III.—J. C., aged forty-two. Admitted to the First Surgical Division of the Roosevelt Hospital, April 21, 1921. He had suffered from various forms of digestive disturbance during much of his life. Appendicectomy was done in 1909. Gastro-enterostomy was done in 1912. He had then enjoyed reasonably good health until two weeks before admission to the hospital when he had an attack of bronchitis or broncho-pneumonia. Sixty hours before admission he was seized with very severe general abdominal pain—"doubled up with the cramps." Vomited repeatedly—attacks of vomiting and pain have both continued until the present time. Constipation "very bad" for the past two weeks. Bowels did not move without catharsis, and then only in small quantities. Much worse since pain started. No gas per rectum. When admitted to the hospital he seemed weak, thin, very ill, and in much pain. His abdomen was distended, there was much muscle spasm, and dullness at its lower part. Peristalsis waves were visible.

Operation.—Four-inch incision in right rectus, enlarged to six or seven inches. Abdominal contents under much tension. Small intestine collapsed and appar-

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ently empty throughout its entire extent. In the left side of the abdomen extending from the diaphragm into the pelvis there was an enormously dilated portion of the large intestine. In order to deliver this it was necessary to remove the small intestines from the abdomen. They were temporarily confined in warm moist towels; the distended colon was then found to extend from the ileo-cæcal valve to the beginning of the transverse colon; it was delivered with considerable difficulty. The large intestine below the middle of the transverse colon was not dilated. The constriction seemed to have been caused by hinging of gut at the middle of the transverse colon. The entire ascending colon had been transferred to the left side and had become enormously dilated in that position. An effort was made to push the gas downward from the dilated intestine. This was only partially successful although no definite band of constriction could be found. A rectal tube was inserted through the anus to aid this procedure. The outer layers of the dilated intestine were dark in color and the wall had broken down in several places. It was therefore deemed wiser to leave it outside the abdomen than to make further efforts to return it. The wound was therefore closed in layers to the emergence of the intestine. The distended intestine was then punctured with an aspirating trocar and a large amount of gas withdrawn, also some very foul-smelling fecal material. The afferent and efferent legs of the intestine were sewed together. The intestinal wall was stitched to the skin. Wound was smeared with sterile vaseline. The ascending colon which was still somewhat dilated was left in the dressing and the patient returned to bed in this condition. After two days a part of the protruding intestine was excised and sent to the Pathological Laboratories.

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Macroscopic specimen consists of an opened and somewhat dilated cæcum preserved in formalin. It is more or less cylindrical in shape and measures 13 cm. in the longitudinal axis and varies from 2.5 to 6.5 cm. in transverse diameter across the opened surface. The serosa is rough and has some adhesions. The wall everywhere is thickened measuring in many places 1.4 cm. It is firm and fibrous. The mucosa is smooth and thrown into folds. There are no areas of ulceration, necrosis or hemorrhage. The lumen is patent and varies from 2 to 5.5 cm. in transverse diameter.

Microscopic.—The mucosa is about the normal in thickness, but the submucosa is greatly increased with newly formed connective tissue. The submucosa is vascular and has a round-cell infiltration throughout. The circular muscle is about three times as thick as that shown in Case I, but the longitudinal is about the same in thickness. The serosa is greatly thickened and shows a chronic inflammatory reaction.

He did well. The wound healed firmly to the emergence of the intestine. Clamps were applied to the spur on May 25th. On May 31st the ends of the intestine were sewed together. At the present time he is still under treatment in the hospital.* He is doing well and is gaining steadily in strength. The stoma is not yet entirely closed.

These three cases illustrate various phases of the problem. Case I shows the good result which may come from the removal of a sufficient portion of the enlarged colon. Case II shows that a patient with this disease may drift along beyond the possibility of relief, either medical or surgical, and that this drifting may occur while she is trying to attend to the ordinary duties of life. Cases I and III both illustrate the comparative safety of

* Later note. He left the hospital in good condition with stoma entirely healed July 20, 1921.

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the extraperitoneal two-stage method of resection (Mikulicz). The cases, however, are too few for general deductions. They are only to be considered in conjunction with the extensive literature which now exists.

Consideration of Literature.—As a starting point it should be stated that this literature gives abundant proof that surgical treatment is more successful than medical treatment. For instance, Duval gives 74 per cent. mortality from medical treatment, 34 from surgical treatment. Lowenstein 66 from medical, 48 from surgical. Ladd has given the following tabulation of 118 cases:

	TOTAL	CURED PER CENT.	IMPROVED PER CENT.	UNIMPROVED PER CENT.	DIED PERCENT.
Treated medically	60	12	13	6	67
Treated surgically	58	41	8	3	41

Terry found a mortality of only 27 per cent. in ninety-five cases treated by surgery. Neugebauer, quoted by Hubbard, referred to 123 cases treated medically with only 1½ per cent. of cure.

Surgical Treatment.—The term surgical treatment is a very elastic one and includes many forms of procedure. It is interesting to know how different surgeons have met the problems of this disease; it is also important to know the results of the different forms of treatment which they have used.

A number of tabulations have been made but we know of none which give the statistics of a large number of cases treated by modern surgery. Hence, with the aid of Dr. Charles W. Lester, the literature has been searched for records of operations since 1908, the time of the publication of Finney's

TABLE
Results obtained in 143 cases of Megacolon treated Surgically between 1908 and the present time.

	Total.	Cured.	Improved.	Unimproved.	Died.	Mortality Rate.
One stage resection ..	42	28	3			11 = 26%
Two stage resection Intra-abdominalmethod.....	31	23	2	1	5	16%
Two stage resection Extra-abdominal method (Mikulicz) ..	13	11	1			1 = 8%
Colostomy, cæcostomy, appendocostomy ..	20	3	4			13 = 59%
Short circuiting	22	13		2		7 = 32%
Colon plication	2*	2				
Colopexy	3*	2	1			
Colon plication and colopexy	1*		1			
"Laparotomy"	1				1	
Laparotomy with mas- sage of colon	2				2	
Incision of stricture ..	1			1		
Release of volvulus... .	4*	3	1		1	
Colotomy	1					
Total.....	143	85	13	4	41	= 28.7%

* Other patients who had secondary operations when these procedures had failed to cure are grouped under "two-stage" resections; hence this tabulation does not show the failures of these semipalliative operations.

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article. The search has been carefully made, and without doubt most of the published reports have been found. Some have probably escaped notice, but no report which has been found has been omitted. One hundred and forty-three cases have been tabulated. This includes 136 cases found in the literature, four cases learned of by personal report, and the three cases recorded in this paper.

This table shows an improvement in the general mortality rate. So far as I know 28.7 per cent. is a lower mortality rate than has previously been reported for a large collection of cases, excepting Terry's report of 27 per cent. The mortality rates shown in some previous tabulations are here given:

	DATE	NUMBER OF CASES	MORTALITY RATE
Lowenstein	1907	44	48
Schmidt	1908	71	48
Duval	1910	..	34
Schneiderholm	1915	143	36
Ladd	1921	58	41

The improvement seems to be due to the more general use of rational radical surgical procedures. The increase of such surgical procedure is strikingly shown in comparing the table given above with that prepared by Schmidt in 1908. (See Addenda.) It is noteworthy that although Schmidt's tabulation contained only five two-stage resections intraabdominal and extraabdominal they were all followed by recovery.

From a surgical standpoint the cases may be divided into three groups:

1. Those for whom only colostomy or appendicostomy was done.
2. Those for whom there was only some semipalliative procedure such as short-circuiting, colopexy, relief of volvulus, colon plication, etc.
3. Those for whom more or less of the colon was resected.

The first group should hardly be considered surgical. If patients drift along into semi-moribund condition, and then apply to a surgeon for relief of obstruction, they show the ill effects of whatever treatment they have previously had. If the surgeon is magnanimous enough to try to relieve their condition by colostomy he makes a praiseworthy effort to save life, but he has not had a reasonable opportunity of curing megacolon by surgery. It is not strange that there was a 59 per cent. mortality among the twenty patients in this group. That mortality, however, cannot fairly be considered surgical. Of course this group does not include those cases in whom the colostomy was the first step in a two-stage operation.

Group Two.—Semipalliative operations of the type here mentioned were common in the earlier reports. In this tabulation they represented less than 26 per cent. of the total. Surgeons now prefer procedures which give more prospect of permanent cure. The mortality rate of this group is 7 per cent. higher than for the combined three groups of resections, and the records of "cures" are 18 per cent. less. Secondary operations were frequently done on patients who had previously had one of these semipalliative procedures, but such cases are recorded under two-stage operations.

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Group Three—Partial Colectomies.—At the present time the main surgical interest centres in the problem of removing as much of the enlarged colon as is practicable and this is the obvious procedure. There are three main methods of doing this:

1. In one stage, removing a portion of the colon and uniting the divided ends within the abdomen either by end-to-end, end-to-side, or lateral anastomosis.

2. Using two stages for intra-abdominal resection. There are many variations of the intraabdominal two-stage method, a preliminary colostomy may provide for washing out the colon before the resection, and may provide a vent afterwards. The cæcostomy or appendicostomy may be done for a vent at the time of the resection. A short-circuiting may be done first and a removal of the excluded intestine later. A release of a volvulus or colopexy or colon plication may be done first and a resection later.

3. An extra-abdominal resection may be done in two or more stages. The portion of colon which is to be removed may be mobilized and delivered outside the abdominal wall before it is opened, preferably through a separate incision, after stitching the intestine to the abdominal wall and closing the primary incision completely and the secondary incision to the point of emergence of intestine, the lumens of the gut are temporarily closed and the desired portion of colon ablated. The continuity of the intestine is later established by removing the spur and sewing the ends of the intestine together.

The dangers of these procedures diminish in the order given. The table gives the mortality rates as 26 per cent. for one-stage resection, 16 per cent. for intraabdominal resection in two stages and 8 per cent. for extraabdominal resection in two or more stages (Mikulicz). These rates may vary with the next table made, but they correspond in fair measure with other statistics.

Each surgeon will endeavor to fit the procedure to the individual case. The proportion of cases of real megacolon which are suitable for a one-stage resection must be small. The main dangers come from sepsis and shock. These colons are particularly foul. No doubt some of them can be so cleansed as to make one-stage resection justifiable, but most of them will need some provision for possible infection or leakage at the site of union and possibly a vent for escape of gas from another part of the intestine. The manipulation incident to a one-stage resection is often more than these patients can endure. A simple time-saving procedure is very desirable.

If operation in two stages is decided upon, each surgeon will again endeavor to fit the procedure to the individual case. Extraperitoneal resection (Mikulicz) is often more tedious and trying to patient, nurse and surgeon than other forms of two-stage operations.

It has never been generally popular, as is shown by the limited number of reported cases. It is, however, becoming more popular and is a very valuable resource; it is doubtful, for instance, if Case I would have survived and obtained so good a result under any other form of operation. It has

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the great advantages of rapidity, diminished manipulation of the intestine and diminished shock to the patient. It gives less likelihood of troublesome adhesions. The danger of infection is very greatly diminished since the portion of intestine which is to be ablated is delivered outside the abdomen before it is opened.

It is quite possible that further development of the two-stage intra-abdominal method may meet these advantages; that the colon may be adequately cleansed; that suitable provision for possible leakage at the suture line may be made and that an intestinal vent may be provided which will prevent the accumulation of gas. Also that the patient's strength may be so conserved as to provide a reasonably safe margin for extensive operation.

It is, however, to be remembered that most of these operations are done under adverse conditions. The patients are weak and debilitated, the procedure is an extensive one, the resources of surgery are put to a maximum test and the procedure which gives the least danger must often be selected, even if it implies a more disagreeable convalescence than one would wish. Hence the pro-stage extraabdominal method (Mikulicz) is our safest resource for a larger proportion of these patients.

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ADDENDA.

*Schmidt's Tabulation of Cases of Hirschsprung's Disease Treated by Surgery.
Prepared 1908. Beitr. z. Klin. Chir. Vol. lxi p. 682.*

		Cure.	Improved.	Not Improved.	Died.
Expl. Lap	11	3	2	1	5
Puncture	4				4
Artificial Anus	10	1		1	8
Colotomy	5				5
Plication	2	1		1	
Colopexy	6	4	1	1	
Anastomosis (short circuit)	16	6	3		
1 Stage Resection	12	6		1	7
2 Stage Resection	4	4			5
Extraabdominal Resection	1	1			
Total	71	26	6	5	34 = 48%

Age of Patients recorded in Table I.

Age.	Total	Cured.	Per Cent.	Im- proved.	Per Cent.	NotIm- proved.	Per Cent.	Died.	Per Cent.
Under 6	27	10	40%	3	12%			12	48%
6-10	17	10	59%			2	12%	5	29%
11-20	21	16	76%			1	5%	4	19%
21-40	37	27	75%	3	8%	1	3%	5	14%
41-60	22	15	68%					7	32%
Over 60	11	4	36%	1	9%			6	55%
Not Stated	8	7	87%					1	13%

Cause of Death.	Patients recorded in Table I.	Number.
Peritonitis		16
Shock and Collapse		13
Embolus		4
Pneumonia		2
Hemorrhage		1
Other Causes		5

THE MANAGEMENT OF PELVIC ABSCESS IN ACUTE APPENDICITIS*

BY ELLSWORTH ELIOT, JR., M.D.

AND

OTTO CARL PICKHARDT, M.D.

OF NEW YORK N. Y.

THE lesions of an infected peritonitis of appendical origin are quite analogous to those of the soft parts. This is especially the case in the early stages of infection and it is only after the discharge or removal of the resulting abscess contents that a material difference may be noted. In the soft parts gravity unquestionably dictates the drainage of an abscess cavity at its most dependent portion. On the other hand, satisfactory drainage of abscesses, even of those involving Douglas' cul-de-sac, can be obtained through an opening in the anterior abdominal wall. This apparent contradiction, in the abdomen, of the law of drainage may be accounted for by the fact that the rhythmical contraction of both the thoracic and pelvic diaphragms constantly directs fluid abdominal contents toward any adventitious opening in the abdominal wall as long as the path of communication remains unobstructed. Furthermore, this same movement in the direction of least resistance is favored by the counterpressure resulting from the more or less intermittent involuntary contraction of the abdominal muscles themselves, as well as by the peristaltic activity of the smooth muscle fibres of the intestine. The resultant activity of these different forces comprising intraabdominal pressure accounts for the difficulty frequently experienced in preventing the prolapse of mobile abdominal contents through an operative incision and readily explains the drainage of inflammatory or hemorrhagic abdominal exudate through an opening in the abdominal wall.

This general "law," however, does not apply to all parts of the abdomen alike, for, in the upper part, drainage of the subphrenic spaces through an anterior opening is rarely satisfactory without siphon attachment. In this location the beneficial effect of the peristaltic activity of the small intestine is largely lacking, while the mobility of the adjacent diaphragm is seriously impeded if not entirely suspended by fibrinous exudate, and more especially by the pressure of the accumulated fluid.

Then, too, the overhanging osseous and cartilaginous thoracic wall, together with the adjacent solid and more or less fixed abdominal viscera, prevent the normal contraction and obliteration of the abscess cavity, which is ordinarily so deeply placed that its contents are more likely to be compressed upward against the diaphragm by the contraction of the abdominal muscles than toward any opening anteriorly.

* Read before the American Surgical Association, June 14, 1921.

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Although quite analogous in their resistance to infections, the fact that the reparative power of the peritoneum is superior to the reparative power of the tissues of the abdominal wall cannot be too strongly emphasized. This is illustrated by the fact that while the discharge from the intraperitoneal portion of an abscess rapidly decreases in quantity and quickly assumes a healthy type, the divided tissues of the abdominal wall regularly undergo appreciable and occasionally extensive necrosis, associated with an abundant foul discharge that continues until healthy granulations are established. This contrast in the relative reparative power of the peritoneum and abdominal wall is perhaps most striking where, after the removal of an acutely distended but not perforated gangrenous appendix, the abdominal incision is closed without drainage. Although, in many of these cases, infection occurs in the suture line, the underlying peritoneum ordinarily escapes. The reparative power of the peritoneum is also well illustrated in one of the cases of this series in which, after the evacuation of an appendix abscess of some days' duration, a loop of small intestine forming the wall of the abscess cavity was found to have so extensively sloughed as to require resection with an end-to-end anastomosis. Prompt healing occurred without the slightest indication of an intestinal fistula, the adjacent pelvic abscess being drained in the usual way.

Drainage of pelvic abscesses by the suprapubic route exclusively does not meet with universal approval. One year ago MacLaren, in a paper read before the American Surgical Association, advocated supplementing abdominal drainage with a counteropening through the rectum or vagina, such an opening, at times, immediately preceding the abdominal incision. In this paper he referred to the recently published report, by Rullison, of all cases operated on at the Presbyterian Hospital, New York, in 1916, in which no instance of this method of drainage was employed, with the comment that by its use in appropriate cases the mortality of 9.1 per cent. might have been materially reduced.

Statistics such as Rullison's are always interesting although, because of the inevitable differences in the operative and post-operative methods employed by different surgeons in the care of these patients, conclusions may prove very misleading. Such statistics, however, serve a useful purpose in providing an opportunity to judge the relative value of different methods of treatment and they should always be collated and arranged with this end in view. On the other hand, deductions based on a series of cases such as MacLaren's, in all of which the principles of treatment were identical, are not only interesting and valuable but highly instructive.

The fact that the writer has never utilized a counteropening through either rectum or vagina in the drainage of a pelvic abscess complicating acute appendicitis is in such marked contrast to the experience of MacLaren that it seemed to justify the further consideration of this subject. With this object in view the writer has made a careful study and analysis of the treatment and results of 351 cases of this lesion that have come under his personal observation during the past twenty-one years (of which 314 are taken from

the records of the Presbyterian Hospital). From this series are excluded a number of fatalities in desperate cases which scarcely survived the operation twenty-four hours and in which no form of drainage could have exercised any favorable effect. In this series of cases the gross pathology has varied according to the duration and type of the infection as well as the location of the appendix.

Prior to perforation, an abundant, odorless, occasionally turbid fluid exudate has been found, free from pathogenic organism and reparative in character. In this group of cases primary union was frequently obtained either without drainage or where precautionary drainage for thirty-six hours only was employed. Occasionally infection of the suture line developed and rarely the escape of a purulent odorous collection on the withdrawal of the drain at the end of thirty-six hours necessitated its replacement. After perforation has taken place the exudate changes into foul, fetid pus, and, irrespective of the location of the appendix, drainage in these cases is always required. If the appendix overhangs the pelvic brim, pelvic abscess is inevitable. If the appendix is retrocaecal, pelvic abscess is not infrequent, although there may be no apparent connection between it and the abscess about the appendix. It is quite evident, therefore, that in all cases in which the peritoneal cavity is opened for the removal of an acutely inflamed appendix the pelvis should invariably be searched for pus. Only in those cases in which a perfectly walled-off abscess may be opened without entering the peritoneal cavity should this search be omitted. In this latter group (no cases of which are included in this paper) the efficacy of anterior drainage is generally acknowledged.

The incision adopted in the treatment of this series of cases has been invariably the intermuscular. This has served both for the removal of the appendix and the drainage of the pelvic abscess. The splitting of the muscle in preference to its division conserves the muscle strength of the abdominal wall, favors an early return of its power to contract and materially contributes to the restoration of normal intraabdominal pressure. These forces together tend to check a spreading intraperitoneal infection and serve to conduct the flow of the purulent discharge to the drainage opening in the abdominal wall. By the use of this incision the wound heals more quickly and firmly with less chance of the development subsequently of a ventral hernia. Should such a hernia develop, its repair is both simple and satisfactory.

Attention to other operative details materially promotes the efficiency of subsequent drainage.

The removal of the appendix, and consequently of the source of infection, the insertion of a purse-string suture or, when that is impossible, the reinforcement of the appendix stump by the superposition of an omental flap, the minimum handling of the small intestine, the thorough evacuation of the pelvic abscess and the careful cleansing of the cul-de-sac with saline irrigation are important steps of the operation. The pelvis is irrigated with the shoulders of the patient elevated, the intestinal loop being held gently aside

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TABLE I

Date.	Type of drainage.	Replacement drainage.	Number of cases.	Complications.						Cured.	Died.	
				Average number of days, cured.	Uncomplicated.	Complicated	Complications only.	Actual.	Per cent.			
Jan., 1900-	(a) Mikulicz; (b) sterile gauze; iodofrom gauze	Gauze pack-ing	39	0	32	38	5.5	4	10	2	5	1
Nov., 1900	(a) Iodoform gauze or sterile gauze and rubber tube; (b) Mikulicz rubber tube	Same as original	30	±	28	32	44	4	10	1	2.5	0
Feb., 1904	(a) Rubber tubes and gauze wick	Cigarette only	24	+	27	31	44	7	29	0	0	0
Mar., 1905	"Collar" cigarette	Rubber tube and cigarette only	33	0	24	24	30	1	3	0	0	0
May, 1902-	Rubber tube and cigarette	Same as original	7	+	26	27	32	1	14	0	0	0
Nov., 1908	"Collar" cigarette	Same as original or rubber tissue	27	0	25	26	37	2	7.5	0	0	0
Feb., 1904-	Rubber tube and cigarette	Cigarette or catheter	3	+	21	21	21	0	0	0	0	0
Dec., 1904	Rubber tube and cigarette	Cigarette or rubber tissue or catheter	72	0	20	23	44	4	5.6	1	1.4	1
Jan., 1905-	"Collar" cigarette	Cigarette	27	0	25	26	37	2	7.5	0	0	1
1907	Rubber tube and cigarette	Cigarette or catheter	3	+	21	21	21	0	0	0	0	0
Mar. and Apr., 1912	Rubber tube and cigarette	Cigarette or rubber tissue or catheter	72	0	20	23	44	4	5.6	1	1.4	1
1908-1912	Cigarette only											
June, 1911- present	Rubber tube and gauze	Catheter	70	+	20	23	41	4	5.7	1	1.4	5
Total	wick		314	++	++	++	++	27	8.6	5	1.6	7

Secondary abscess,
case number.

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by the pressure of a long, narrow retractor against a previously inserted pad. When concluded, and the pelvis has been sponged dry, the drain is inserted to the bottom of the cul-de-sac before the withdrawal of the retractor and pad. After firm compression of the adjacent abdominal wall and bimanual compression of the right ileocostal space have either excluded or removed all further exudate, the abdominal incision is closed, rather loosely, around the projecting tube with interrupted chromic-gut sutures. The primary abscess cavity, if paracæcal or retrocæcal, is similarly drained through the same opening, or, if situated above the crest of the ilium, through a counteropening in the flank.

For about two years, in the first part of this period, the primary drain consisted of a Mikulicz tampon of plain or iodoform gauze, the incision being only partially closed. The severe pain occasioned by the withdrawal of this drain as well as by its replacement, together with the risk of a prolapse from the rupture of intraperitoneal adhesions (which actually occurred in one instance at the initial dressing five days after operation), led to its being discontinued and to the substitution of a rubber tube enmeshed in gauze. It is quite possible that the use of an investing rubber dam would have eliminated both the physical discomfort and the risks of the Mikulicz tampon. It has never been employed, however, as other methods of drainage have proved thoroughly satisfactory.

In 1902 two or more cigarette drains were substituted for the enmeshed rubber tube, and this method of both primary and secondary drainage was continued for ten years. During this same period the combined use of a cigarette drain and rubber tube was occasionally employed, and for three years a cigarette drain inserted through a rubber tube equal in length to the thickness of the abdominal wall was quite generally used. This rubber "collar" was designed to facilitate drainage by preventing too sudden approximation of the separated muscle planes.

In 1911 laboratory investigation demonstrated that capillary drainage by means of a cigarette drain was practical for the serous but not for the cellular part of purulent material, and that within a few hours its drainage value became greatly impaired even for serous discharge. This method was therefore discarded, although it had generally given satisfaction, in favor of the simple rubber tube containing a narrow wick of gauze projecting slightly at either extremity, in order that whatever advantage might accrue from the use of capillary drainage in the first few hours after operation might be retained. The withdrawal of this form of primary drain as well as that of the tampon and cigarette drains, at the end of four or five days, invariably releases an appreciable amount of pent-up purulent material which with ideal drainage should have previously escaped into the dressing. It has further been learned that this undesirable blocking of the discharge can be avoided only by the removal of the drain within the first thirty-six to forty-eight hours after the operation. That such a simple remedy was not immediately adopted was due entirely to the difficulty experienced in the

TABLE II
SECONDARY ABSCESES

Date.	Case No.	Type of drainage.	Replace- ment drainage.	Postopera- tive devel- opment (day).	Location.	Amount.	Character of pus.	Treatment.	Result.	Operative findings.	Autopsy findings.
Feb., 1902	8138 (A. W.)	Mikulicz and two rubber tubes into pelvis	Same	14-21	Pelvis	2 oz.	Different from abdominal pus	Incision.	Spontaneous rupture.	Died 23 d.	Pelvic abscess about 2 oz.; general peritonitis; purulent character and of a different character from pelvic abscess.
June, 1902	8170 (H. S.)	Mikulics and rubber tube	Same	4	Pelvis	1 pint	Thin	At dressing a loop of gut drawn up into wound and a half	Died 5 d.	Cured 5 d.	Pinger in pelvis containing 1 pint of thin pus; no kinks or obstructions of intestines of dull color; fibrinous flakes; a distinct band in iliac fossa constricting foul pus
April, 1907	5135 (M. C.)	"Collar" cigarette	Same	7	Behind and to left of rectum	1 oz.	Foul	Exploratory; ileostomy and drainage	....	Cured 5 d.	Small intestines of abdomen nine hours later
1908	7511 (E. M.)	Cigarette	Same	5-7	Abdominal wall; right lumbar	1 oz.	Yellow	Right flank	....	Cured 29 d.	Mass not palpable per rectum.
1908	7507 (J. B.)	Cigarette	Same	12-17	Peritoneal left lower quadrant	2 oz.	Streptococcus	Left lower quadrant	....	Cured 44 d.	Original incision
1909	7607 (J. W.)	Cigarette	Same	7	Left iliac fossa into pelvis	2 oz.	Streptococcus	Left rectus	....	Cured 27 d.	Original incision
1909	7753 (K. D.)	Cigarette	Same	12-19	Abdominal wall, left lower quadrant	+	Streptococcus	Left lower quadrant	....	Cured 34 d.	Original incision
1909	9520 (W. G.)	Cigarette	Same	12-17	Pelvis	++	Streptococcus	Subphrenic	....	Cured 40 d.	Original incision
1914	10172 (F.)	Rubber tube and gauze wick	Catheter	20-38	Subphrenic	3 oz.	Streptococcus and colitis	Original incision enlarged (McBurney)	....	Cured 60 d.	Original incision
1914	(M-43)	Rubber tube and gauze wick	Catheter	8	Above and to outer side of cecum	+	.....	.....	....	Cured.	.....

insertion of the replacement drain before the end of the fourth or fifth day—a difficulty that was eventually overcome by the use of a Nélaton catheter. The rounded extremity and the flexibility of this instrument facilitate an easy, painless passage along a recently formed sinus leading into an abscess cavity, while the fact that the gauze in which its extremity is invested is stained at some distance from the edge of the incision with discharge conclusively demonstrates its value as a drain. At each dressing the character of the discharge from the deepest part of the abscess cavity can be determined by compression of the extremity of the catheter just prior to its withdrawal, and by the use of similar siphon action the entire abscess tract can be rendered practically dry after irrigation. The only reason why the catheter is not used as a primary drain is that, on account of its very flexibility, the passageway leading into the cul-de-sac would probably be much more sinuous (and therefore less suitable for the effective discharge of the abscess contents) than the much straighter channel secured by the use of a relatively unyielding rubber tube for the first thirty-six or forty-eight hours. The catheter, then, is used both as a drain and for purposes of irrigation, the latter begun four days after operation and continued until the offensive character of the discharge disappears. At the end of eight to ten days the intraperitoneal part of the sinus is practically obliterated and the closure of the superficial wound follows in a few days. To sum up, the establishment of a direct passage into the deepest part of the abscess cavity is obtained by the use of a medium-sized rubber tube for thirty-six hours, and the continued unobstructed patency of this passage is secured by the daily introduction of a Nélaton catheter. So satisfactory has this method of drainage proved that its use has been extended to the drainage of infectious processes in all parts of the abdomen with equally good results.

While the value of effective drainage in these cases must not be minimized, the ultimate closure of the abscess tract is unquestionably hastened by irrigation. As this practice has become more and more a matter of routine, the average duration of healing has progressively decreased from thirty-two to twenty days. Irrigation also contributes to the comfort of the patient by mitigating the offensive character of the discharge.

The fatalities occurring shortly after operation in this series of cases must be ascribed to the intensity and extent of a far-advanced peritonitis which in no way could have possibly been diminished by any method of drainage. A study of the results obtained in all other cases seems to justify the conclusion that drainage through a rectal or vaginal counteropening would not have affected materially the mortality. To this statement exception should be made in two instances in which the Mikulicz tampon was employed: In one, twenty-three days after operation, an autopsy showed a collection of two ounces of pus in the pelvis, markedly different in its appearance from the generally distributed purulent exudate of associated diffuse septic peritonitis; in the other, a loop of small intestine prolapsed on the fourth day after operation at the time of the initial withdrawal of the tampon. A

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rapidly developing peritonitis then led to a secondary laparotomy with the discovery of at least a pint of thin pus in the pelvis. The patient did not long survive the operation.

In cases drained by cigarette drain, between 1902 and 1912, secondary abscesses developed in five cases. These appeared as early as the fifth and as late as the nineteenth day after operation. The location of the abscess in one instance was the neighborhood of the gall-bladder,* in another, in the right lumbar region; in two instances, in the left lower quadrant near the anterior parietal peritoneum, and in the remaining three, in the left side of the pelvis—in only one of which was the abscess palpable through the rectum.

Six of these secondary abscesses were opened through an anterior incision. In one, the abscess discharged spontaneously into the original abscess tract. All recovered, and in only one patient—in whom, in addition to an abscess in the left side of the pelvis, the small intestine had become constricted by a fibrinous band—was the condition serious. A prompt recovery, however, followed the evacuation of the secondary abscess and an ileostomy for the relief of the obstruction.

Since 1912, during which period primary drainage by a rubber tube containing a small wick of gauze has been employed, two instances of secondary abscess have developed: one above and to the outer side of the cæcum, and the other in the right subphrenic space. In both, recovery followed the evacuation of the pus through an appropriate incision. There has been no instance of the formation of a secondary abscess in the pelvis.

Of all secondary abscesses complicating appendicitis those occurring in a part of the abdomen remote from the pelvis must be ascribed to failure to remove all infectious foci, and it is reasonable to infer that those appearing in the left lower quadrant near the anterior abdominal wall are due to a similar cause. Those occurring in the deeper part of the pelvis, especially where an elastic swelling can be palpated through the rectal wall, probably indicate defective drainage. In those that have no connection with the original drainage tract the cause may at least be said to be doubtful.

Further valuable evidence of the efficiency of pelvic drainage is derived from the results of two autopsies occurring respectively thirteen and eleven days after operation. In the first instance drainage by means of collar cigarette, and in the second instance two cigarette drains had been employed. In neither was any accumulation of pus found in the pelvis. The case reports also show four instances of secondary enterostomy done six, seven, six and six days, respectively, after the primary operation. In one, already referred to, there was a collection of pus on the left side of the pelvis near the rectum, having no communication with the original drainage tract. In the remaining three the pelvis was entirely free from purulent exudate. In three of these cases a collared cigarette drain and in the fourth a rubber

* Not included in table.

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TABLE III
CASES REQUIRING SECONDARY OPERATION—NOT FOR ABSCESS

Date.	Case No.	Primary drain.	Secondary drain.	Type of operation.	Operative findings.	Result.	Autopsy findings.
June, 1900	7735 (E. M.)	Iodoform gauze	Same on second day	Exploratory median incision on fourteenth day	Considerable serum in general cavity; no odor and no pus; intestines congested. Intestines somewhat congested; were separated till bottom of pelvis was exposed; no abscess; a Mikulicz tampon of iodoform gauze to pelvis	Died on twenty-first day.	
Dec., 1901	8086 (M. B.)	Mikulicz and rubber tube wrapped in iodoform gauze; no pelvic abscess	Same	Exploratory median incision on fourth day		Died on fifth day	
Mar., 1906	1906 (A. P. I.)	"Collar" cigarette	.....	(a) Intestinal obstruction on fifth day; (b) enterostomy second day	(a) Serous fluid in pelvis without odor; kink in small intestine relieved; no special relief. (b) At first great relief, through free evacuation, both through fistula and rectum.	Died on eleventh day	Around stump of appendix no sign of either ligature; a small black slightly fistula 4½ feet above valve; no granule in either large or small intestine.
Nov., 1907	5596 (A. B.)	Cigarette to pelvis; "collar" cigarette to iliac fossa	Fourth day, all out	Ileostomy on sixth day; first incision left ileocecal space; second incision midline above umbilicus	Small amount of free serous fluid; the walls of small intestines showed a number of fragments of plastic material; exploration of pelvis showed no accumulation of pus	Cured by thirty-third day.	
1909	9772 (S. H.)	Cigarette		Gauze packing because of hemorrhage	Twelfth day, considerable hemorrhage after dressing	Died on thirteenth day	Small pockets of pus between matted coils of small intestines; no collection of pelvic pus; tubes and ovaries normal.

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tube containing a small wick of gauze had been used. The sole fatality occurred in one of the cases drained by a collared cigarette.

Analysis of the evidence presented by these different conditions justifies the conclusion that, with the exception of the two cases treated by Mikulicz tampon and two instances of secondary abscess in the deeper part of the pelvis, the drainage of the cul-de-sac has been satisfactory. It is at least not too much to state that during the past ten years, since the inauguration of the present method of drainage, the absence of a single instance of secondary formation of abscess in the pelvis seems to exclude the need of the use of a rectal or vaginal counteropening.

The possibility of inefficient drainage either of the cul-de-sac or of some contiguous part of the pelvis, however, must always be kept in mind. To forestall surprise, a daily leucocyte count should be taken and a rectal examination should be made at least once in forty-eight hours in search of tumefaction or tenderness. It is both interesting and important to note that usually both of these symptoms may be elicited. The tenderness, however, is decidedly less than prior to the operation, and the sense of swelling—the result probably of the matting together of intestine and omentum—gradually subsides and entirely disappears in the course of a few days.

By one without experience in the use of rectal or vaginal drainage, any criticism or discussion of its value is out of place. Perhaps the possibility of the entrance of additional causes of infection through such an opening may be advanced as a theoretical objection. Furthermore, the possibility of a persistent sinus must not be overlooked. Finally, if vaginal section in the treatment of pyosalpinx in any criterion, the possibility of inadequate drainage through a vaginal opening must be recognized. The writer also apologizes for suggesting that the evacuation and drainage of a secondary pelvic abscess deeply seated in the cul-de-sac, in the absence of any indication of a spreading peritonitis, could be advantageously carried out through the rectum or vagina rather than through a fresh incision in the anterior abdominal wall.

In conclusion, the writer presents this method of drainage of pelvic abscess in full knowledge of the fact that numerous surgical lesions admit of satisfactory treatment in one of several ways, and with no intention to exclude other methods of treatment which in the hands of his colleagues may have yielded equal if not superior results.

ON THE MECHANICS OF PRODUCTION AND THE TREATMENT OF SPIRAL FRACTURES*

BY EMMET RIXFORD, M.D.
OF SAN FRANCISCO

THE problem presented by spiral fractures of the long bones is one of special importance, first because of the great frequency of these fractures, and second, because the anatomical and functional results of their management by the usual technic leave much to be desired.

Figures differ as to the relative frequency of spiral fractures because of more or less uncertainty as to the definition, *i.e.*, in addition to pure torsion fractures there are mixed forms in which torsion may be active in the production of the fracture but plays a relatively small part, and again there are opportunities for difference of opinion as to what proportion of the so-called oblique fractures may properly be classified as spiral fractures.

For purposes of the present paper only those fractures are called spiral which are typical and are the result of torsion. Stinson (Edition 1912) says spiral fractures are rare, Scudder (1911) does not mention them, Zuppinger estimates that 26 per cent. of all fractures of the tibia are spiral and 39 per cent. of all fractures of the shaft of the tibia. Probably these figures are low.

That the results of the treatment of spiral fractures by the process of reduction and fixation, and even by traction, are unsatisfactory anatomically, and functionally may easily be seen and will as readily be admitted by almost any clinician who will carefully criticise and check up his results. Non-union is frequent in spiral fractures of the lower third of the tibia, irregularity of the bone in case of union is the rule with a persistent and symptom producing external rotatory deformity in the majority of cases with frequent anterior flexion deformity and more or less shortening. We often see abduction deformity as well, sometimes of sufficient degree, especially when associated with external rotation to be the cause of breaking down of the arch of the foot with resulting pronation and flat-foot.

A proper understanding of spiral fractures and the special difficulties of their management must rest on a clear conception of the mechanism of their production. Fortunately this is not difficult, though it receives scant attention even in our better texts.

That spiral fractures of the shafts of the long bones are the result of torsion has long been known and abundantly proven both clinically and experimentally—witness the unusually interesting case of Doctor Monks of this association in which no force other than torsion was active. In this case two men were sitting with forearms flexed to a right angle, elbows on a

* Read before the American Surgical Association, June 14, 1921.

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table between them, striving by pressing their palms together to see which could force the other's hand to the table, thus producing powerful external rotatory stress on each humerus. One humerus gave way, breaking in a spiral. Precisely the same thing occurred in a personal case in which the right humerus gave way in a left-handed spiral fracture as a result of violent effort in throwing a base-ball.

If a fracture is produced by a mechanism so simple that it can be followed and analyzed one would expect the form of the fracture to be typical under the laws of pure mechanics. These conditions obtain most perfectly in the case of spiral fractures where not only the general form of the fracture, but also the direction of the spiral is determined by and corresponds to the direction of the axial rotation. Moreover most of the clinical phenomena pre-

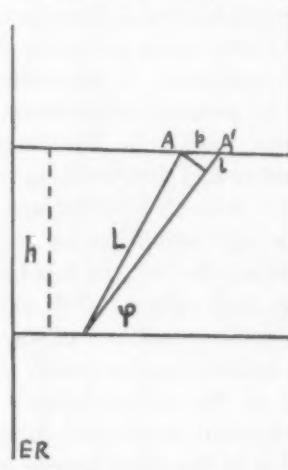


FIG. 1.—After Zuppinger.

sented by spiral fractures are such as necessarily must obtain as a consequence of these mechanical relations.

The fundamental principle determining the direction of the spiral and the pitch were worked out by Zuppinger (*Brit. z. kl. Chir.*, 1906, lli, 391, and 1909, lxiv, 562), applying Hooke's law to the effect that the lengthening of a given bar of any material under tensile stress is proportional to its original length and to the tensile force active in producing the lengthening. If a bar of any cross section, *e.g.*, a cylinder of length h is subjected to axial torsion, and if L be the length of any line drawn *ad libitum* on its surface, the effect of the torsion is to move the point A to some point A' in the direction of the torsion, l would then be the amount of lengthening of L resulting.

The following equation would represent the relations :

$$S = a \frac{l}{L}$$

in which S is the tensile force and a some constant depending on the nature of the material. By simple algebraic substitution it is evident that

$$S = a \frac{P}{h} \sin \Phi \cos \Phi$$

for small values of ρ . S is a maximum where sine and cosine are equal, *i.e.*, at $\phi = 45^\circ$.

EMMET RIXFORD

From this it follows that the more brittle the material the nearer the angle approaches 45° . Thus if one twists axially a chalk crayon, a material approaching the limit of brittleness, he finds that it breaks consistently in a spiral of almost exactly 45° pitch, two limbs of the spiral being connected by more or less longitudinal fracture.

The material in giving way breaks at right angles to the direction of the tensile force. Therefore a bar subjected to left-handed torsion, as in the figure, breaks in a right-handed spiral and, *vice versa*, right-handed torsion causes left-handed spiral fracture.

Since in less brittle material there is a greater yielding or stretching under tensile stress—in this case torsion—the angle ϕ is small, consequently the pitch of the spiral fracture is steeper, thus in the long bones of children, spiral fractures are much more oblique than in adults, which accords with clinical experience—extreme cases occurring in which the spiral fractures are almost longitudinal fractures. It thus follows that in children many spiral fractures are capable of practical adjustment without open operation.

The effect of torsion may readily be illustrated by cutting a piece of rubber tubing in a spiral manner and then twisting it axially—a right-handed spiral will be opened up by a left-handed torsion and per contra a left-handed spiral will be opened up by a right-handed twist.

The almost universal finding clinically of left-handed spirals in the right upper and lower extremities and right-handed spiral fractures in the left upper and lower extremities is the result not of any particular characteristic of constitution of the bones in question, but purely of the mechanical necessities of the case, a measure of the overwhelmingly greater frequency with which the extremities are subjected to external rotation rather than internal.

It is but a coincidence that in the development of the extremities a rotation occurs in the long bones in the sense of internal rotation which is supposed by some to produce a sort of spiral grain in the bones (Fleming). Witness the backward position of the feet in the so-called siren deformity where internal rotation is inhibited by fusion of the fibulae. Here the spiral development of the femora continuing, the upper end of each femur gives way in an anterior congenital dislocation of the hip (Dreesmann).

If a right femur or humerus be subjected to internal rotatory stress sufficient to break it, *e.g.*, right-handed torsion, a right-handed spiral fracture will result in spite of any left-handed spiral grain to the contrary, and this right-handed spiral fracture will be identical, except for the reverse direction of its spiral, with the usual left-handed spiral fracture of the right femur or humerus.

The spiral fissure may extend completely around the full circumference of the bone even more than once. In the case of the young man who broke his humerus throwing a base-ball, the spiral fissure when exposed in open operation was traced at least twice around the bone.

Since in a given case of torsion effective in breaking a long bone the whole bone is under stress in an infinitude of potential spirals, determination of the particular spiral in which the bone is about to break is quite fortuitous,

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depending simply on the location of some weakest point. Of course this is ordinarily single, but it is not a very violent supposition to conceive that there may be two or more weakest points so nearly equal that the bone may break in two or more parallel spirals. With this idea in view, and after hunting for some years, I finally found a case of spiral fracture of the tibia with parallel spiral fissure in a young adult. Of course others have found similar cases. Recently my associate, Doctor Rumwell, found one with two parallel spiral fissures in a girl of twelve in the Stanford out-patient clinic and Doctor Blaisdell, of the Stanford Medical School, succeeded in producing by pure torsion parallel spiral fractures in the humerus of a cadaver.

If the torsion force acts no farther the bone is merely spirally fissured, it is not actually separated into two fragments. Precisely this fracture does occur occasionally in young people as is proven by the X-ray.

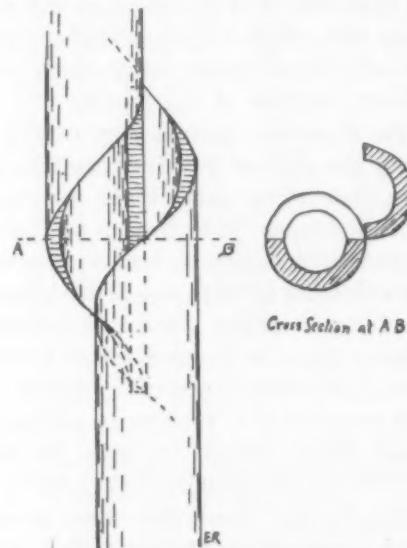


FIG. 2.—Right handed spiral fracture with fragments rotated to 90°.

It is not necessary to invoke other forces such as bending moment as does Zuppinger to explain the occurrence of the vertical component of spiral fractures, for this part of the fracture by which the bone is separated into two fragments necessarily follows from continuance of the torsion.

That bending moment, however, has some effect in determining the particular location of the fracture is probable as offering an explanation (Zuppinger) of the fact that in the majority of instances of spiral fracture of the tibia, the spiral component of the fracture is ordinarily on the anterior aspect of the bone and the longitudinal component behind.

If the torsion force continue after the bone has given way in spiral fissure an entirely different distribution of forces instantly takes place. Tensile forces develop on the inner surface of the bone and compressive on the outer, as may readily be seen by reference to the diagram (2). The bone

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forces now active on its inner surface, it breaks in a nearly longitudinal fracture, folding outwards on its external surface and on the periosteum as a hinge. This longitudinal fracture connects two adjacent limbs of the spiral completing the separation of the bone into two fragments. Since the spiral fracture precedes the longitudinal, the spiral fissure is ordinarily found to extend a considerable distance at one or both ends beyond the point of intersection of the longitudinal element of the fracture.

Since the bone is pulled apart along the spiral element of the fracture the periosteum is uniformly torn along this line, and because in the production of the longitudinal component of the fracture the bone is folded towards its outer surface, the periosteum is not torn along that part of the fracture. This fact is of the greatest clinical significance as will be seen farther on.

Along the spiral part of the fracture, however, the periosteum, as said above, is torn; more than that, it is pulled apart and therefore torn irregularly, leaving numerous tabs which fold around the fracture surfaces, and if not removed or replaced militate against union much as similar tabs of aponeurosis do in transverse fracture of the patella.

By reference to the diagrams again it may readily be seen that in the process of disengaging the tips of the fragments in the instant of completion of the fracture, their sharp points being accurately mortised in their corresponding niches, will frequently be broken off, because the majority of long bones are of substantial thickness between periosteum and marrow, varying of course, but averaging perhaps one-fifth of the diameter of the bone.

So much for the effects of torsion alone. In practice we find that other forces are active in many cases at the moment of fracture and afterwards. Especially is this true in the lower extremities where weight bearing, augmented in its effect by momentum in running or jumping, adds an important element of longitudinal thrust. While it would be interesting mathematically to estimate the effect of such longitudinal thrust in increasing the pitch of the spiral by adding shearing stress, this effect is unimportant clinically. Much more important is the effect of longitudinal thrust if active after fracture is complete and the fragments rotated as described above. For by this same rotation the fragments are completely disengaged and offer no resistance whatever to longitudinal thrust. Thrust will then cause the fragments to pass by each other and the periosteum on the side of the vertical component of the fracture not being torn apart will be stripped from one or both pointed ends of the fragments but will otherwise remain as a "periosteal bridge." Clinically, one generally finds the tips of the fragments in spiral fractures bereft of periosteum. The fragments under these circumstances are so free to move in any direction that their sharp projecting points and knife-like edges may lacerate muscles, nerves, blood-vessels, neighboring joints, etc., and often perforate the skin, making the fracture compound. In being moved about these long, sharp points often catch between them tough, fibrous tissues such as intermuscular septa as well as nerves and blood-vessels, any of which may effectively prevent reduction of the fracture.

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Moreover the long points of the fragments may be broken off by bending the limb at the point of fracture and this the more easily occurs because the long points are weakened by the fact that the spiral fissures often extend far beyond their intersections with the longitudinal component of the fracture.

From the above considerations and the complicated form of the spiral fracture it is evident that if the fracture is not perfectly reduced there is practically no reduction at all, *i.e.*, if there is any displacement whatever there is a great deal of displacement. The untorn "periosteal bridge" being attached along the sides of the bone more or less opposite to the spiral component of the fracture is short, and it is made still shorter by the deposition beneath it of chips of bone or blood clot, or if a little time has elapsed

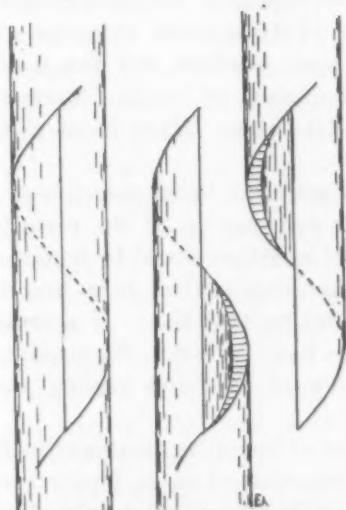


FIG. 3.—Right-handed spiral fracture seen from side of longitudinal component.

since the occurrence of the fracture by inflammatory tissue or new bone. This short "periosteal bridge" effectually prevents overcoming of rotatory displacement and is one of the reasons for the common clinical experience of the persistence of external rotation after union of a spiral fracture.

From a practical standpoint spiral fractures of the long bones are never reduced except in open operation. But it may be argued that by traction and splinting shortening may be overcome and the fragments may be laid alongside each other, overlapping by their long tongue-like processes, affording sufficient contact to secure bony union. It may readily be seen from the diagrams that unless the fracture is accurately reduced it gapes widely along the spiral component and where contact is established the raw edge of the bone is to a considerable extent in contact with the outer surface of the torn but not stripped up periosteum. A dead space is there present, lined on one side by connective tissue (outer surface of the periosteum),

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which may grow into it more rapidly than bone, militating strongly toward non-union.

Thus may readily be grasped the reason for the common clinical experience that union begins on the side of the "periosteal bridge," *i.e.*, on the side of the longitudinal component of the fracture, the intact periosteum furnishing an effective barrier to the ingrowth of connective tissue at this point.

On the other hand, when the fracture is accurately reduced the fragments fit with such mathematical accuracy that they afford a very considerable degree of stability. Theoretically in the typical case there is but one direction in which stability is lacking and that is in the direction of the original axial rotation by which the fracture was produced.

It would therefore be logical in the management of such fractures to support this weak point. Like accurate reduction of the fracture this can only be accomplished in open operation, but then it can be done most simply and effectively with a minimum of traumatism to the tissues and with a minimum of implanted hardware. There is no need for long plates with many screws.

By giving scrupulous attention to the principle of producing a minimum of traumatism, avoiding stripping up of the periosteum and with a good aseptic technic the risk of infection would be minimized, and it would seem that the advantages of securing perfect form and function otherwise impossible would warrant taking that risk. If operation is done early, *i.e.*, before secondary changes have occurred, the required manipulation is easy and there is no necessity of excessive pulling and prying and tearing the tissues.

While not an advocate of operative treatment in fractures in general, or even in any very large proportion of cases, I submit that in my hands I have had far greater satisfaction in view of the results obtained in early operative reduction and fixation of spiral fractures of the long bones than in treatment by traction and external fixation. It is not fair to the treatment of fractures by open operation to have operation relegated to the position of last resort. It should be possible in most fractures to determine before treatment of a fracture case whether proper position can be maintained before with or without open operation. There should be no such thing as operating for mal-union for it can always be determined in the first few days of treatment of a fracture case whether proper position can be maintained before embarrassing secondary changes have occurred.

The rapid degeneration of bone under non-use, readily appreciated by following the increase of transparency to the X-rays, militates against later union. It is for this reason, and for the maintenance of joint integrity, that massage of muscles and mobilization of joints is so important in the treatment of fractures. Of greater value than massage and passive motion in maintaining circulation and nutrition of the injured limb is functional demand, a fact that has long been evident from a clinical standpoint, though

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not always carried out in practice as systematically as it should be. For the experimental determination of the value of functional demand on the growth of bone I would refer to the beautiful experiments on the bones of young dogs by Doctor Haas, of San Francisco, in which the beneficial effect of early resumption of function is shown in contrast with the findings in an ample series of control experiments.*

If fractures of the long bones can be so adjusted and held as to permit early functional demand, non-union will have lost one of its chief causes. In transverse fractures, if the fragments can be set on end and held so, even if the area of contact is but a fraction of their surfaces, the arm and forearm can be used a great deal and in the lower extremity weight bearing may early be established. In spiral fractures if accurately adjusted in early operation and the weak part of the mechanism (the spiral) properly supported a considerable functional demand can be made within a comparatively short time.

In view of the foregoing it would seem to be worth while to attempt to establish a definite technic for the management of spiral fractures, at least those in which the mechanical phenomena can accurately be estimated, and a technic ought not to be difficult to find on which surgeons could agree.

In spiral fractures of the long bones the advantages of the early operative treatment are so great that I would submit that, barring definite contraindications to operation in general, all spiral fractures of the long bones in adults and adolescents and some in children be managed by early open operation and would submit the following as a technic which has given excellent results in my hands:

1. Determine the location and form of the fracture by X-ray plates so taken as to locate that part of the spiral portion of the fracture which is opposite the longitudinal component.
2. Cut down on this spiral part of the fracture and remove all detached chips of bone and larger fragments, if not required as a part of the splintage, and drill both fragments, if possible, *in situ*, or with a minimum of disturbance of their position, locating the holes at such points as after reduction will make the line joining them lie obliquely to the spiral in such wise as most effectively to resist torsion displacement. In general this line will be transverse to the axis of the bone.
3. Pass a stout silver wire through the drill holes.
4. Reduce the fracture by traction, rotation and leverage, taking care not to break the bone, lifting out any periosteal or fibrous tabs from between the fragments along the spiral, but taking care not to strip up the periosteum. Draw the wire taut and twist, hammering the ends down against the bone.
5. Close the wound and apply some sort of efficient retentive appliance, a properly fitting Thomas splint or plaster-of-Paris cast.
6. Remove the retentive appliance frequently for massage, mobilization of the joints and electrical development of the muscles and arrange for the patient to make functional demand at the earliest reasonable moment.

* To be printed in *Archives of Surgery*.

INEQUALITY OF THE LOWER EXTREMITIES FOLLOWING FRACTURE OF THE SHAFT OF THE FEMUR IN CHILDREN

BY EDWARD D. TRUESDELL, M.D.
OF NEW YORK CITY

THE treatment of fracture of the shaft of the femur in children presents a variety of problems based upon a consideration of conditions peculiar to children themselves, as well as the peculiarities of the fracture. In determining upon the adequacy of a certain method of treatment in a given case it is customary to make such assumptions as that union will take place or that callus formation will be sufficiently abundant to fill such spaces between fragments as in the adult might mean non-union. While the existence of a strong tendency to union and to generous callus formation is commonly appreciated, it is not so commonly appreciated that fracture of the shaft of the femur in children frequently, perhaps commonly, causes stimulation of the growth of the injured bone. In reviewing the final outcome following this injury in children in a series of cases two interesting facts have presented themselves. First, that permanent shortening of the involved extremity was obviously less frequent than following similar injuries in adults, even where at the termination of treatment shortening had existed; second, that it was not uncommon to find some degree of lengthening of the injured leg; this, too, where shortening had existed originally. In fact, excessive lengthening was more common than excessive shortening, and while an undesirable amount of overriding had been modified or corrected by treatment when necessary, there had been no provision included in the usual methods of treatment to prevent or limit excessive elongation of the broken bone with corresponding lengthening of the affected extremity.

A brief description of five cases possessing this lengthening is presented herewith.

CASE I.—A. P., age nine. Injured August 25, 1918. A fracture of the shaft of the left femur near its centre. Line of fracture irregularly transverse. There was two inches overriding. Under anaesthesia an end-to-end reduction of the fracture was accomplished, apposition being imperfect but satisfactory, and a plaster spica dressing applied. Frequent X-ray examinations indicated that the engagement of the fragments was maintained. There was slight settling upward of the lower fragment, due to absorption under pressure of bony irregularities at point of contact of fragments. At the time of discharge from the hospital, six weeks after injury, one-half inch shortening of the extremity was noted. Two years and two months after injury the affected extremity was found to be three-eighths of an inch long. In the standing position there was obvious tilting upward of the pelvis on this side. There were no symptoms complained of that might be attributed to the injury; no disability.

CASE II.—H. E., age fourteen. Injured September 27, 1920. A fracture of the shaft of the left femur just above its centre. Line of fracture of the long

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oblique variety, with one-half inch overriding. Under anaesthesia reduction was attempted and a plaster spica dressing applied. One week after injury there was marked increase in the overriding, the extremity shortened one and one-half inches. Edmonton tongs with traction applied, the overriding reduced to one-half inch. Two months after injury there was one-half inch lengthening of the affected extremity, which at ten months (July, 1921) had increased to one inch.

CASE III—C. K., age five. Injured March 23, 1915. A fracture of the shaft of the left femur, just above its centre. The X-ray revealed a comminuted fracture, line of fracture of the long oblique variety, and a large third fragment present. There was marked displacement with overriding. On the eighth day after injury a Steinmann pin was inserted through the condyles of the femur to correct seven-eighths of an inch shortening. Discharged from hospital eight weeks after injury, the extremity one-quarter of an inch short. One year and nine months, and again five years and ten months after injury, one-half inch lengthening was observed.

CASE IV.—P. G., age eleven. Injured December 5, 1918. Fracture of the shaft of the left femur in its lower third. Line of fracture practically transverse with two inches overriding. Two attempts under anaesthesia failed to improve displacement of fragments. A Lane plate was applied on the twelfth day after injury. To obtain reduction and favor end-to-end contact a small portion of bone was removed from the end of one fragment. Discharged from hospital nine weeks after injury, the affected extremity three-eighths of an inch short. Two years and one month after injury the extremity found one inch long. Marked tilting upward of pelvis upon same side in the standing position. Lane plate still present and well tolerated.

CASE V.—V. B., age eight. Injured May 26, 1911. A fracture of the shaft of the left femur in its upper third. Line of fracture practically transverse, just below the lesser trochanter. Excessive angular deformity, lower end of upper fragment presenting just beneath skin. Other methods failing to bring about satisfactory reduction, a Lane plate was applied on the fourteenth day. Small portion of bone removed from lower end of upper fragment to secure reduction and satisfactory apposition. Three months after injury affected extremity noted one-half inch short. Fifteen months after injury one-half inch lengthening observed. Observation seven years after injury and again nine years and a half after injury, showed three-fourths of an inch lengthening of the injured extremity. Lane plate still present and well tolerated.

Apparently the situation of the fracture is irrelevant in its relationship to the stimulation of bone growth, since overgrowth has been as great in fractures of the upper, middle and lower thirds of the femoral shaft. Nor was the epiphyseal cartilage directly involved in any case. Lengthening may occur whether the method of treatment be by simple reduction, the employment of the pin or the tongs, or the application of a Lane plate, and to an equal degree. In four of the five cases there was shortening of the extremity at the termination of treatment, while in two there had been actual removal of bone from the ends of the fragments. In none had overriding been overcorrected or even fully corrected. While the growth of the fractured bone may be accelerated following its injury, there is apparently no compensatory activity, either early or late, upon the opposite side, and an inequality produced under these circumstances is seen to persist after ten years. Evidently the possibility of excessive growth of a fractured femur during the

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period of childhood is of sufficient importance to deserve some consideration in the application of treatment to this injury. An extremity one inch short at the termination of treatment would generally be considered a poor result. So far as the patient is concerned it is immaterial whether the inequality of the extremities be due to shortening or lengthening. Even with the tilting of the pelvis and the slight compensatory curvature of the spine there was noted a remarkable freedom from all symptoms and an absence of disability of every sort. Moderate degrees of shortening of the extremity, due to overriding of the fragments, in cases of fracture of the shaft of the femur in children is evidently of less significance than in corresponding injuries in adults, and the possibility of post-traumatic acceleration of growth of this bone in children should be kept in mind in passing judgment upon the efficiency of a particular method of treatment and particularly when some radical procedure is contemplated for the correction of overriding.

NOTE CONCERNING KERATIN AND KERATOHYALIN IN TUMORS OF THE HYPOPHYSIAL DUCT*

BY PERCIVAL BAILEY, M.D.

OF BOSTON, MASS.

ASSOCIATE IN SURGERY, PETER BENT BRIGHAM HOSPITAL

In a series of tumors of the pituitary region from the clinic of Dr. Harvey Cushing which I have recently had opportunity to examine, there occurred three of the hypophysial duct. In 1904 Erdheim,⁴ in discussing tumors of this region, postulated as a differential point that "cholesteatomata" contained keratohyalin and hypophysial duct tumors did not. This statement has been contradicted among others by Bartels.² Recently Duffy,³ in examining some tumors of the hypophysial duct, noted certain granules. He seems to have accepted the judgment of Bartels that they were keratohyalin and investigated them no further. Similarly Jackson⁵ in his cases seems to have accepted Erdheim's judgment and says that granules of keratohyalin are not found.

Absolutely fresh material removed at operation being available, it seemed worth while to investigate these granules as fully as possible. Incidentally reports of three cases may be added to the fifty-five collected by Duffy. For demonstrating the keratohyalin there was employed the modification of Pick's cresyllight-violet method which I had previously used for keratohyalin in pearly tumors¹ (Perlgeschwülste, sometimes called cholesteatomata). Unna's alum haematoxylin method⁶ was also used. For keratin the gentian violet and safranin methods of Reinke⁶ were used, and also the Gram method proposed by Ernst with the Weigert modification. The sharpest pictures were obtained by staining heavily with Babes' anilin safranin and decolorizing with acid alcohol. The keratin-containing cells retain their bright red color after the rest of the section has been completely decolorized.

The clinical data concerning these cases will be given as briefly as possible, since we are concerned chiefly with certain histological details.

I. Benign squamous epithelial cyst.

This cyst may well have contained papillary or teratoid characteristics, but since only a small fragment was examined it must be placed here.

CASE I.—P. B. B. H. Surgical No. 13453. *Cyst of hypophysial duct origin.*
Operation—evacuation. Recovery.

November 2, 1920. Admission of S. N., age thirty-three, an engineer, with complaint of headache and blurring of vision. Referred by Dr. A. F. Longeway, of Great Falls, Montana.

Present Illness.—Began to have occasional frontal headaches in October, 1920. About the same time he noticed double vision and blurring. His libido

* From the Surgical Clinic of Dr. Harvey Cushing, Peter Bent Brigham Hospital, and the Laboratory of Surgical Research, Harvard Medical School, Boston, Mass.

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began to diminish. Shortly afterwards there developed a mucopurulent discharge of the right nostril.

Positive Findings.—The patient had a soft, pale, dry and finely wrinkled skin. Axillary and pubic hair were very scanty. There was marked drowsiness and slightly subnormal temperature. Bilateral optic atrophy and bitemporal hemianopsia were also present. The basal metabolism was -16. The X-ray showed a saucer-shaped sella with slight erosion of the anterior clinoid processes.

November 6, 1920. *Operation.*—By the usual transsphenoidal procedure. The floor of the sella was very thick and it was opened with difficulty. Through it protruded a thin membrane, and when it was incised a milky, turbid fluid poured out of what was evidently a cyst. The fluid contained a mass of beautiful cholesterolin crystals.

Microscopic Examination.—A single very small fragment of the cyst wall was submitted for examination, which was fixed in Regaud's fluid.

It was seen to consist of a short strip of stratified epithelium along one margin and for the rest of normal pars distalis of the character usually seen in the periphery of the gland. Eosinophilic, basophilic and chromophobe cells were clearly distinguishable, the latter predominating.

The epithelium, evidently the wall of the cyst, consisted of two or three layers of irregularly cuboidal cells with lightly staining, almost homogeneous cytoplasm. The cells of the inner layer were larger, more regular and more lightly staining. Nearly all the cells were extensively vacuolated. The nuclei were vesicular and also stained very lightly. In the cytoplasm of these cells were seen often discrete granules of keratohyalin of varying size. The cells of the basal layer of epithelium contained rarely a few fine granular mitochondria.

II. *Adamantinomatous tumors.*—These cases are called by Roussy and Clunet⁷ "Neoplasiques ou tumeurs heterotopiques, epitheliomata pavimentaux."

CASE II.—P. B. B. H. Surgical No. 14011. *Tumor of the hypophysial duct, cystic. Operation—partial extirpation. Fatality. Autopsy.*

February 15, 1921. Admission of H. S., age eleven, a schoolboy, with complaint of loss of vision and frontal headache with vomiting. Referred by Dr. A. Heard, of Austin, Texas.

Present Illness.—Since six years of age the patient's eyes had troubled him. In 1916 vision in the right eye began to fail rapidly and was lost entirely in June, 1919. Headaches had been severe since 1919 and frontal in location. They were occasionally accompanied by projectile vomiting. Since 1919 vision had been failing in the left eye. Sometimes he had a ravenous appetite. He had been wearing the same clothes for two years and during this time had gained fifteen pounds in weight, but had not increased in height.

Positive Findings.—There was found total blindness in the right eye and a temporal defect in the left visual field. Primary optic atrophy was present in both eyes, more marked in the right. He was under height and overweight for his age. His skin was dry, sallow and finely wrinkled. The genitalia were very small. The X-ray showed separation of the suture lines, considerable generalized convolutional atrophy of the inner table of the skull, and marked changes in the sella turcica. The floor of the enlarged sella was depressed into the sphenoid sinus and the dorsum sellæ was very thin.

February 18, 1921. *Operation.*—This was a somewhat difficult transsphenoidal procedure owing to the boy's small nose. The sphenoidal cells also were poorly developed and there was a thick median septum. It was therefore difficult to clear the sella, which was quite large. The exposure was very small and on

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incising the dura a solid tumor was found. A fragment was taken and examined immediately. On finding an epithelial tumor a considerable portion of the sellar contents was removed. Suddenly there was a gush of cloudy, milk-white fluid, evidently from a cyst, and the whole area collapsed and began pulsating. It seemed perfectly dry and was closed.

Post-operative Course.—The patient soon developed a cerebrospinal fluid leak and succumbed to meningitis.

February 28, 1921. *Autopsy* (Dr. C. E. Locke).—A tumor was found in the region of the pituitary. "It was apparently solid and about 2 cm. in diameter. The tumor seemed to encircle the chiasm." Some fibrinopurulent exudate around the base contained numerous staphylococci.

Microscopic Examination.—The material was fixed in 10 per cent. neutral formalin, Zenker and Regaud's fluid. Along one side of the section were found a few columns of normal pituitary cells, mainly chromophobe. The rest of the material consisted of a typical squamous, epithelial, adamantineomatous tumor.

The tumor was composed of almost a solid mass of squamous epithelial cells with typical intercellular bridges. Scattered around were numerous areas of cystic degeneration, with here and there a blood-vessel. There was but very little connective tissue around the blood-vessels only.

The cytoplasm of the cells was very scanty and around each nucleus was a row of very fine granular mitochondria. Occasionally areas of keratinized cells were found and, around these cells, with granules of keratohyalin.

CASE III.—P. B. B. H. Surgical No. 13832. *Suprasellar Tumor of Hypophysial Duct, cystic. Unusual case with Choked Discs. Subtemporal Decompression. Subsequent Transfrontal Operation. Extirpation. Recovery.*

January 7, 1921. Admission of F. D., a dentist, age thirty-four, with complaint of blindness in the right eye and headache. Referred by Dr. Alex. Quackenbos, of Boston, Mass.

Past History.—Luetic infection in 1908, badly treated for the first three months, but later thoroughly treated for three years.

Present Illness.—Began in June, 1919, with sharp stabbing pains in right supraorbital region when coughing or sneezing. In March, 1920, he noticed some blurring of vision in the right eye. In June, 1920, he was found to have a temporal defect in the right visual field. In October, 1920, spinal puncture revealed a positive globulin test and thirty-four cells per cubic millimetre. The Wassermann was negative. Headaches continued and began to be associated with vomiting in November.

Positive Findings.—There were found bilateral choked disc of 2-2½ D. and a bitemporal hemianopsia. The visual acuity in the right eye was 5/200 and in the left 20/20. Tendon reflexes brisk to exaggeration. The X-ray showed some evidence of bone destruction with bone activity in the region of the sella turcica, the dorsum sellæ itself participating in this change. There seemed to be some calcification just above the sella turcica associated with the destruction process in the dorsum.

January 5, 1921. *Operation.*—This was the usual subtemporal procedure. A somewhat wet and elastic brain bulged on incising the dura—a typical hydrocephalic brain. A puncture was first made in the superior temporal convolution with negative findings, and a second puncture through the lower convolution obliquely backward, striking the ventricle. A large amount of fluid was secured, greatly lowering tension. Examination of the fluid showed three cells per cubic millimetre.

January 25, 1921. *Discharged.*—Decompressed area was tense. Discs were elevated about 1½ D. No improvement had occurred in visual fields. The patient was told to return in a few weeks.

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February 1, 1921. *Second Admission.*—His headaches had recurred and no improvement had occurred in vision.

February 7, 1921. *Second Operation.*—This was a transfrontal procedure. The bone flap was reflected from the right frontal region, exposing the tense dura. A needle was inserted into the ventricle and 60 c.c. of fluid escaped. It was then possible to elevate the frontal lobe from the level of the orbit without difficulty. On incising the dura at the margin of the sphenoidal crest there began to extrude from the incision as it was enlarged the bulging wall of the cyst, and before the incision could be enlarged as much as was finally necessary, the cyst ruptured and a purulent-looking, watery fluid, containing an abundance of cholesterolin crystals, began to extrude itself. The cyst must have been a very large one, for about 40 c.c. of this material was finally secured and an equal amount must have been lost. Between the right olfactory nerve and the chiasm was a solid portion of tumor largely made up of calcareous fragments which widely separated the legs of the chiasm and extended deeply into the pituitary fossa. This mass was finally dislodged and tilted out of its bed. The pituitary scoop, which made it possible to detect the rough inner surface of the cyst owing to the lime deposit upon it, was used, and what seemed to be the larger part of the cyst was removed. By pulling upon the fragments of cyst wall a large portion of it was dislodged and drawn down toward the region of the third ventricle, though by no means all of it, for it was feared damage might be done.

February 28, 1921. *Discharged.*—Fundus showed no measurable swelling. Headaches were entirely relieved. Visual fields filled out almost to normal limits and visual acuity to 20/20 in the left eye and 20/40 in right.

Microscopic Examination.—The tumor found at operation was a typical cystic epithelial adamantinomatous tumor of the hypophysial duct. It was composed of a mass of squamous epithelial cells with typical intercellular bridges. There were numerous areas of cystic degeneration and numerous areas of keratinized cells. Many cells contained keratohyalin granules. Around the nuclei of the epithelial cells were a few fine granular mitochondria. The keratinized cells, however, contained none. The keratohyalin granules took the acid fuchsin sharply.

COMMENT

In all three of these tumors were cells containing granules which stained heavily by the methods ordinarily used to demonstrate keratohyalin in the skin. They are in all probability of the same nature. In two of the tumors cells were also found which stained heavily by methods used to demonstrate keratin in the skin and hair.

It should be noted that the fluid from two of the cysts reported here contained cholesterolin crystals. In the other case they seem not to have been looked for. They will be found in many cysts of the hypophysial duct as Erdheim admits. In Erdheim's masterly paper it seems to me that among his so-called cholesteatomata the Cases XIII and XV are similar to Case I of this report. Both are said to have contained hair. It has been pointed out elsewhere that the term "cholesteatomata" is an unfortunate one and allows such cysts of the hypophysial duct which contain cholesterolin crystals, as well as other growths, such as the so-called cholesteatomata of the middle ear, to be confused with the "tumeurs perlées" of Cruveilhier.

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TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting Held April 27, 1921

The President, DR. WILLIAM A. DOWNES, in the Chair

TENDON TRANSPLANT FOR WRIST-DROP

DR. JAMES N. WORCESTER presented a man, thirty-six years of age, who had received a compound fracture of the right humerus in September, 1908. Non-union resulting he was operated on and a silver wire inserted. Immediately following the injury musculospiral paralysis was present. An attempt was made in March, 1909, to repair the nerve but without result.

DR. ALFRED TAYLOR exposed the nerve, a four-inch defect of which was found. A nerve transplant was done and also a silk suture was inserted between the biceps muscle and the radius. There has been no return in nerve function after a period of nine years since last operation. The condition is now, March 1, 1921, one of complete paralysis of the extensor muscles of the wrist; there is no extension of fingers. Motions of elbow normal. Power of flexion very much lessened due to separation of the biceps and the brachialis anticus muscles from their insertions.

Operation: At the Reconstruction Hospital, March 9, 1921. Procedure: Incision over insertion of flexor carpi radialis, tendon cut and freed by blunt dissection upwards for a distance of three inches; similar incision and procedure over insertion of flexor carpi ulnaris. These two loosened tendons were brought out through a small opening in the skin three inches above points of insertion. Median incision then made over dorsum of wrist and extensor tendons exposed. Tendon of extensor brevis pollicis, extensor longus pollicis and extensor indicis split and tendon of flexor carpi radialis passed under skin and through the split and sutured with fine silk. Extensor tendons of third, fourth, and fifth fingers split in similar fashion and tendon of flexor carpi ulnaris brought under skin and through these and sutured with fine silk. Fascia closed over line of suture with fine plain gut and skin closed with silk.

Post-operative Course: Following operation, patient developed pneumonia and was very ill for a few days. Motions of the wrist were begun immediately post-operatatem and active motions particularly encouraged. The wrist-drop disappeared after operation and power of extension has gradually increased to present state. At present he has almost complete extension of the fingers, the thumb and index-finger working together. The wrist-drop has disappeared, although the power of extension was not normal but was improving.

FLAP TRANSPLANT FOR BURN OF HAND

FLAP TRANSPLANT FOR DEFECT OF SOLE OF FOOT

DR. JAMES N. WORCESTER presented a man, twenty-five years of age, who in France received a bullet wound of the plantar surface of the right foot. He was admitted to the Reconstruction Hospital, August 14, 1919.

On the plantar surface of the right foot over the metatarsophalangeal joint was an area of very dense scar tissue extending entirely across the sole of the foot and about two inches in length. This scar tissue was adherent to bones and tendons; there was no motion present in the toes. In the centre of the scar tissue was a deep ulcerated area three-fourths inch in diameter, which was extremely painful. Under rest in bed this healed but immediately broke down again when pressure was put on it.

Operation, July 26, 1920: Procedure: Scar tissue dissected away from bone and tendon. A flap was then turned down from the calf of the left leg in shape to correspond to the defect of right sole which was sutured to edges of defect with interrupted silk sutures and plaster cast applied. The pedicle was cut at the end of ten days. The patient was kept in bed for six weeks and at the end of eight weeks he began to walk, using a pad made of rubber bath sponge directly over graft, which has remained entirely healed. Patient walks without pain and is working.

FLAP TRANSPLANT FOR BURN OF HAND

DOCTOR WORCESTER also presented a man, aged thirty-eight years, who received a burn involving the whole of the left hand on March 24, 1919, in a gasoline explosion. He was admitted to the Reconstruction Hospital September 19, 1919. The whole dorsum of the left hand was involved in dense scar tissue extending from the wrist to the finger tips; the second, third and fourth fingers are rigidly fixed in extension, the little finger shows a partial dorsal dislocation of first phalanx due to contracture. Thumb is dislocated posteriorly, standing out from hand at right angles. There is complete loss of flexion of all the fingers. The scar tissue shows numerous cracks and ulcerations and the circulation is extremely poor. Patient was treated with physiotherapy, using particularly whirl-pool baths, massage and baking. The circulation improved and there was a gradual increase in the movements of the fingers.

Operation January 6, 1920: Scar tissue over dorsum of thumb was excised down to tendons and it was then possible to reduce the dislocation. The defect was covered by means of a flap from the abdomen. The pedicle was cut at the end of ten days and circulation of flap remained good.

Second operation, April 6, 1920: Amputation of little finger.

Under continued physiotherapy motions in fingers and thumb have increased until at present he has an extremely useful hand.

When patient was admitted to hospital, amputation of hand had been advised.

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CANCER OF THE LARGE INTESTINE NOT INCLUDING RECTUM
OR RECTO-SIGMOID

DR. JAMES I. RUSSELL read a paper with the above title, for which see p. 755, June ANNALS OF SURGERY, vol. Ixxiii.

DR. JOHN ERDMAN said that in his personal work 1916 to 1920 he had sixty-four cases of large intestinal growths, of which twenty-five were growths of the recto-sigmoid, and the remainder were of the cæcum, ascending colon, transverse colon, splenic flexure, etc. During the same period he had done thirty-nine additional operations of the same kind on private patients elsewhere, making a total of 110 growths of the large intestine. Of these 110 growths, thirty-nine were of the recto-sigmoid, sixty-one of the cæcum, ascending colon, etc.; two were cases of tuberculosis of the cæcum. There were twelve cases involving the hepatic flexure and the right three-quarters of the transverse colon and four involving the left one-quarter of the transverse colon and the splenic flexure. There were twenty-seven sigmoidostomies. A mortality operation of 15 per cent. The general mortality for the entire series, including emergency operations, was 24 per cent. This mortality includes non-operative also.

It had been his custom to do the two-stage operation. He did a cæcostomy in the majority of the cases instead of a sigmoidostomy or a transverse colostomy. It was true that in doing a sigmoidostomy the operative work was a little more difficult. That with a cæcostomy, although more difficult to clean the entire colon, one could readily with care and attention accomplish the act. At the end of ten or fifteen days he did the resection.

He had recently done one lateral anastomosis of the transverse colon and the patient was in the hospital at the present time and making a good recovery. In patients in whom there were metastases in the liver he had not hesitated to do radical work, because patients with metastases in the liver were bound to live twelve to twenty-four months, and if the growth was excised they were much more comfortable, and if an anastomosis could be made it prevented the discomfort of an artificial anus. He had followed this procedure which had been very satisfactory and had afforded a great deal of comfort in many instances.

Two cases of special interest in this connection were the following: Thirteen years ago he removed a transverse colon in a young man of thirty-four. The pathologist reported that the growth was a colloid carcinoma. He recovered from the operation, lived eleven years, and died of sarcoma of the right shoulder. The röntgenologist was absolutely certain that the growth in the shoulder was not a carcinoma. Five weeks ago he had operated on this man's sister, who was thirty-one years of age at the time, for a growth in the sigmoid. The pathologist reported that the growth was an adeno-carcinoma with colloid degeneration.

CANCER OF THE LARGE INTESTINE

DR. CHARLES N. DOWD stated that the diagnosis of these cases had puzzled surgeons for many years but that some progress had been made and the average time of diagnosis is much earlier than it used to be.

One of the most important elements in this kind of surgery is the determining of the amount of intestine which should be resected. This question depended largely on the path of lymphatic drainage and the consequent spread of infection.

Jamieson and Dobson did some very valuable work on this subject several years ago. They demonstrated that the lymphatics at the centre of an arterial arcade must travel a considerable distance parallel with the intestine before reaching the main arterial trunk; therefore, in many instances, the excision of a large section of the colon is desirable. The ascending colon, the lower end of the ileum and the hepatic flexure should be removed in one section to secure immunity from infection which follows the course of the ileo-colic vessels.

In the transverse colon the lymphatic current easily reaches the region of the median colic artery. Hence only a moderate resection is needed in this region. In the region of the splenic flexure the resection should include about one-half of the transverse colon and a large part of the descending colon.

In the region of the sigmoid colon the theoretical resection should extend from the lower descending colon to the middle portion of the rectum, but this is usually inadvisable since the mechanical difficulties are so great. Moreover, there is only a slight lymphatic supply to this region and the local excision of growths there has been attended with a considerable measure of success. Hence a resection extending from the upper end of the sigmoid to the lower end of the sigmoid is advised.

In doing this work one must always be guided by the patient's condition and the degree of resection must be adjusted to that. However, the colon is easily mobilized by cutting the outer leaf of its peritoneum and there is probably more error in attempting too little resection than in attempting too much.

Again there is sometimes a difficulty in making a diagnosis between diverticulitis and carcinoma even on the operating table and, of course, complications arise from that cause. A very moderate resection in diverticulitis is sufficient.

As to the method of operation Doctor Dowd said that he did not advocate the Mikulicz operation for the ascending colon but in the transverse colon, the descending colon and in the sigmoid this operation gave so much safety that most patients were willing to accept a moderate delay in healing for the sake of securing this safety.

DR. WILLY MEYER called attention to a method of cæcostomy which he had devised and considered very simple and satisfactory. He first made McBurney's intermuscular incision and removed the appendix, then he sutured the appendix into the peritoneal wound. In emergencies it was opened immediately, otherwise after twenty-four hours. For that purpose he penetrated

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the gut with the tip of a straight Paquelin cautery. With the discharge of the eschar the hole enlarged so that in a few days one could easily introduce one's forefinger and palpate. One could then pass a soft rubber tube to the transverse colon for the purpose of irrigation. If there was a stricture the fluid would regurgitate and come back through the wound. Doctor Meyer asked the members, if called upon to do a caecostomy, to give this method a trial. If one got these cases in the advanced stage when they were vomiting one could employ this procedure easily under local anaesthesia and still hold to the two-stage operation. Later, after the radical excision of the tumor, the cæcal opening closed spontaneously.

In cases of less marked obstruction Doctor Meyer favored the two-stage operation, beginning with a lateral anastomosis. This obviated the necessity of establishing a temporary artificial anus. In a patient who had been under the care of others for cholecystitis for several years, Doctor Meyer said he found a large tumor of the ascending and transverse colon. These colonic tumors sometimes grew very slowly. In this case he first did an ileocolostomy; in the second stage he resected the tumor and inverted either end of the gut. In the specimen there was found a pretty tight constriction. The lumen was just large enough to pass a pencil; yet the patient had bowel movements. After several years she developed haematuria and in examining her cystoscopically, a sessile tumor of the bladder was found. This was promptly excised, the bladder closed with ureteral drainage. She recovered again and was alive to-day without recurrence, sixteen years after operation.

DR. W. S. SCHLEY said that in connection with the question of technic it was an advantage to use the intermuscular incision. For the right side it was almost indispensable in caecostomy both for a permanent or temporary opening. For the Mikulicz operation it was extremely easy and practical and greatly facilitated subsequent closure. He had used it for fifteen to eighteen years and had found it practical in every way. The abdominal muscles acted well as a cut-off, particularly on the left side.

DOCTOR AUCHINCLOSS stated that in doing an anastomosis in cases not acute he made use of an ileocolostomy as had been done by others. The gut was not opened except when clamped. He used Kocher clamps. The clamp was put on the side of the large gut its mouse-tooth point brought up to the surface. The whole of the included two walls of the gut was then burned off. The small gut was then clamped straight across and burned through so that there were two cauterized clamped holes to be sutured. This was done on one side of the clamps and then with the clamps rotated over the suture was continued around the gut. Just before the suture ends were tied the clamps were slipped off and the anastomosis completed by tying the ends of the two suture lines to their respective starting points.

The colon anastomosis case shown at the last meeting done by the above method was an end-to-end anastomosis in the rectum and the case did not leak nor have a stricture. He was just beginning some attempts to carry

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out this method on dogs; but the first attempt in a dog was unsuccessful because the clamps used were entirely too large for the purpose. It was his hope to continue, however, and to study the sections of repair following such anastomoses from the standpoint of hemorrhage and stricture.

DR. WM. A. DOWNES spoke of anastomosing around the growth to prevent the formation of an external fistula and said he had had several very good results. One woman with carcinoma of the transverse colon had gone along for four years after an anastomosis around the growth and then died of intercurrent disease. This procedure was a very good thing to bear in mind.

As to the bismuth meal, in cases of suspected growths in the intestine bismuth enema was always given first, and if there was evidence of obstruc-

With reference to diverticulitis, Doctor Downes cited a case who had been treated palliatively for four months. He then had a sudden chill and a large quantity of pus was discharged from the bladder. This continued four or five days. At operation it was found that an abscess had formed and had ruptured into the bladder. The opening into the bladder was closed and a rubber dam placed between the bladder and the sigmoid, and though there was a faecal fistula for seven or eight months the man recovered.

DOCTOR ERDMAN said that where there was no obstruction it was not necessary to do a cæcostomy, nevertheless he felt that a preliminary cæcostomy or colostomy was necessary because in that way the toxins were washed out. The statement that it was sepsis that kills answers the question as to the necessity for a preliminary colostomy or cæcostomy.

DOCTOR RUSSELL agreed with Doctor Dowd in the value of the two-stage Mikulicz operation, particularly in the left half of the colon, but preferred the one-stage primary resection in the right side and transverse colon. It is true that the two-stage operation kept the patient in the hospital a little longer, but it was much safer. It was well known that it was sepsis that killed these patients.

There was an operation described about twelve years ago which he had done once or twice but had never done it in the large intestine. In this operation the lumen was burned across close to a narrow crushing clamp, the clamps approximated and a suture done over them, the suture being tied at the convex border of the intestine as the clamps were withdrawn. The lumen was then established by rubbing the charred ends together through the continuity of the wall of the intestine. In this way the intestine is not opened at any stage during active operative procedure. In opening the intestine one was almost sure to get some contamination and, as is well known, is highly infectious in the large intestine. The patients did well for about forty-eight hours, then became sick and many died. To avoid such occurrence it is better to do a two-stage Mikulicz operation, for it is not a question of twenty-three or seventy-two days in the hospital but one of getting the patient well and avoiding sepsis.

CORRESPONDENCE RUPTURE OF UTERUS

EDITOR ANNALS OF SURGERY:

SIR: In the Transactions of the Philadelphia Academy of Surgery, published in the August number of the ANNALS OF SURGERY at p. 251, the mistake has been made of attributing to me case reports of "Rupture of Uterus During Attempts at Version," "Double Amputation of the Thigh for Senile Gangrene." Both these case reports were made by Dr. Irvine M. Boykin.

Very truly yours,

ASTLEY P. C. ASHHURST.

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Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS *of* SURGERY

227-231 S. 6th Street

Philadelphia, Penna.